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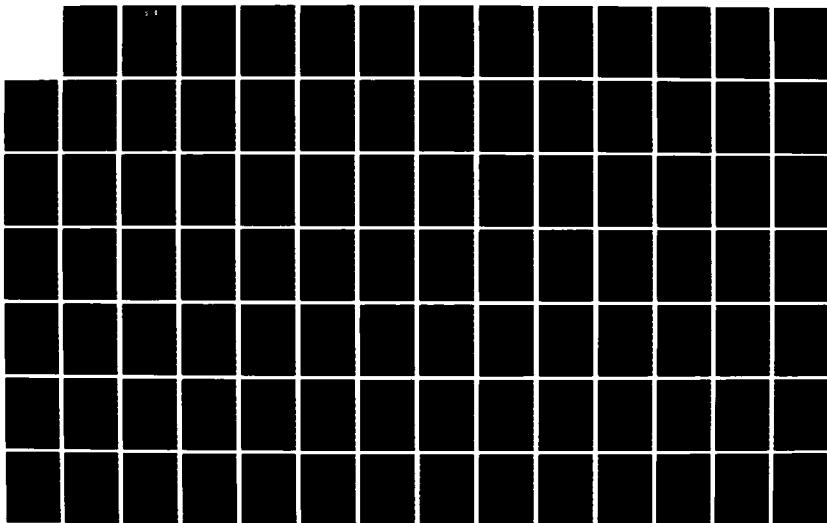
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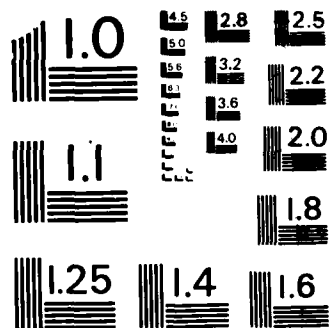
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THE EFFECT OF WORD-UNIT SPACING UPON THE READING  
STRATEGIES OF NATIVE AND NON-NATIVE READERS OF CHINESE:  
AN EYE-TRACKING STUDY

DISSERTATION

Presented in Partial Fulfillment of the Requirements for  
the Degree Doctor of Philosophy in the Graduate  
School of The Ohio State University

By

Michael Erwin Everson, B.A., M.A.

\* \* \* \* \*

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1986

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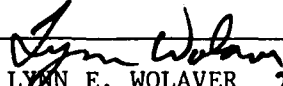
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1. REPORT NUMBER AFIT/CI/NR 87-23D	2. GOVT ACCESSION NO. <b>AD-A176719</b>	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) The Effect of Word-Unit Spacing Upon the Reading Strategies of Native and Non-Native Readers of Chinese: An Eye-Tracking Study		5. TYPE OF REPORT & PERIOD COVERED <b>THESIS/DISSERTATION</b>
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Michael Erwin Everson		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS AFIT STUDENT AT: The Ohio State Univ		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS AFIT/NR WPAFB OH 45433-6583		12. REPORT DATE 1986
		13. NUMBER OF PAGES 111
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report)  UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report)  APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED		
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To My Mother

Mary L. Everson

With Love, Esteem, and Gratitude

## ACKNOWLEDGMENTS

My sincere appreciation goes to my co-advisors, Dr. Gilbert A. Jarvis and Dr. Elizabeth B. Bernhardt. Dr. Jarvis was most influential in instilling in me an appreciation of the research process; Dr. Bernhardt served to heighten my interest in the reading process, and made sure that any technical problems experienced with the eye tracking equipment were quickly remedied. My appreciation also goes to Dr. Charles Hancock for his insightful comments after reviewing the dissertation and to my friend and colleague, Dr. Galal Walker, for giving me access to the Chinese language student population and the Xerox Star multilingual word-processor. Gratitude is expressed to my classmates, especially Elizabeth Larson, Leslie Powell, Richard Mann, Edmund Hays, and Miko Harada for their help and encouragement. Grateful acknowledgment also goes to Gerald L. Greer, Thomas N. Tegge, James Silar, Clara Sun Yi-ren, and Ho Shang-hsien, very special teachers who started me on my way to completing this degree so many years ago. To my wife Kathy, and my children, Elizabeth and Paul, I offer my most heartfelt thanks for supporting and tolerating me during the more difficult aspects of the program. Finally, my thanks go to the United States Air Force, the organization that funded my doctoral program, and an organization in which I am very proud to serve.

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## ABSTRACT

The effect upon selected eye movement parameters of manipulating the spacing between Chinese characters in a Chinese language reading passage was examined. Groups of native Chinese, beginning non-native (American) learners, and advanced non-native learners of Chinese read two versions of a beginning level Chinese language reading passage. One version was typeset normally, while the other was artificially typeset so as to reflect the grouping of individual characters or character combinations into word-units.

The differential spacing of the two textual versions did not seem to be disruptive to the native Chinese readers. The advanced non-native group, however, fixated more frequently when reading the artificially spaced version. It is hypothesized that this group may have reached a level of familiarity with reading normally spaced Chinese texts that is disrupted by spacial manipulation; beginning non-natives, on the other hand, may have not as yet acquired a consistent strategy for reading Chinese as witnessed by the fact that their fixation frequency did not change significantly between spacing conditions.

The advanced non-natives demonstrated their greater proficiency over the beginning non-natives by fixating less frequently, making a smaller percentage of regressive fixations, and by achieving a higher reading rate. Qualitative differences in comprehension were also noted, but only achieved significance at the .03 level. Average fixation duration for the two non-native groups, however, was not

significantly different, thus highlighting an index that may reflect the perceptual demands of Chinese orthography upon non-native learners in general.

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## CHAPTER I

### THE PROBLEM

#### Introduction

One of the more noteworthy undertakings in foreign language research has been an attempt to understand how learners develop into competent readers of a foreign language. Unfortunately, empirical evidence dealing with foreign language learning, defined here as "learning the target language in a classroom within a community where it is rarely if ever used for communication outside the classroom" (Oller & Tullius, 1973), has been generally confined to the more commonly taught languages of French, German, and Spanish. Empirical studies in the professional literature dealing with the processes involved when a non-native learns to read Chinese are all but non-existent. Yet, the teaching of reading in the Chinese foreign language curriculum has always held a special place in the minds of professional Chinese language educators. Walker (1984), for instance, states that "in the long run, reading is probably the most important skill a learner can gain from formal instruction in Chinese" (p. 67), while Light (1975) has called the teaching of reading "the major problem in the teaching of Chinese in America" (pg. 70).



If this problem, then, has received professional focus and emphasis, empirical investigation into the reading behaviors of non-native readers of Chinese has not. This is not surprising as research into the more commonly taught foreign languages is still in its infancy. When complicated by the comparatively small populations of students studying Chinese, the small numbers of teachers (Eddy, 1980; Dien, 1985), and from this latter number, the proportion either interested in or qualified to do research, it is safe to say that our empirical data base will remain meager into the foreseeable future. Yet, in spite of these limitations, certain theories have begun to emerge that may prove useful in understanding the processes involved in learning Chinese as a foreign language.

#### Statement of the Problem

To understand how non-native learners approach the reading of Chinese necessitates some initial theorizing about learning a foreign language that involves a switch in orthography. Tzeng and his associates (Hung & Tzeng, 1985; Tzeng, 1980; Tzeng & Hung, 1981; Tzeng, Hung, & Wang, 1977) have theorized about the general role of orthography in the reading process that may have significant bearing on the learning of Chinese as a foreign language. To Tzeng and Hung (1981), the significance of orthography lies in the fact that different writing systems have different script-speech relationships. Thus, the acquisition of reading skills may in fact be hindered by how

the spoken language is represented in print.

As applied to learners of Chinese, Tzeng and Hung's (1981) view of the problems inherent in learning different orthographies seems particularly germane:

"...sometimes our thinking is blocked not because we lack the necessary mental power, but because the graphemic symbols used to represent certain concepts happen to be clumsy and thus require a great deal of mental resource (central-processing capacity) in order to hold them in our working memory, let alone to further operate them" (p. 238).

Thus, in reading a different orthography, different processing strategies may have to be developed by the reader in order to achieve reading proficiency (Tzeng, 1980). Bernhardt (1986) echoes this claim in her hypothesis that "...the apparent inherent difficulties in the learning of non-Western languages and of languages in non-Roman alphabets may be due partially to a set of developmental, perceptual stages through which readers must progress in order to reach a level of preparation for comprehension" (p. 97).

To generate theories concerning these developmental processes, much of the literature dealing with Chinese as a foreign language centers upon the role of the Chinese character itself. Discussion dealing with issues such as the component structure of the character (Liu, 1980), their semantic and/or phonological makeup (DeFrancis, 1984), or the best time to introduce characters into the foreign language curriculum (Liu, 1983; Mickel, 1980; Walker, 1984) are of current interest to professional educators of Chinese. While investigation into these issues is of critical importance, there are

less apparent factors inherent in the way Chinese characters are laid out on the printed page that may also have an impact upon the reading process. One such issue to be investigated in this study is that of character spacing.

### Character Spacing in Chinese

An individual viewing a Chinese text with the lines printed in horizontal fashion cannot help but be struck by the lack of differential spacing between characters; consequently, uninformed opinions have been generated concerning the nature of the Chinese written language. Many conclude that this lack of differential spacing must mean that each Chinese character "stands for a word," but such is not the case. Individual characters in modern Chinese are generally considered morphemes, while most content "words" are actually combinations of usually two characters, or "bimorphemic" in nature (Martin, 1972). When viewed as a horizontal line of print, however, the only spaces in evidence are those that appear between individual characters to insure that each one is viewed separately; consequently, the reader is given no clue from the visual array as to which characters are components of larger combinations. Said more simply, there is no spacing to signify word-unit boundary in Chinese as there is in English.

Although the question of textual spacing in Chinese has not received a great deal of scientific scrutiny, a growing body of evidence suggests that the spacing between words in English language texts is an essential component in facilitating the normal reading process in English. Because Chinese texts are not spaced so as to typographically represent word boundaries, this study will examine the impact of artificially manipulating a Chinese text so that the spacing between characters or character combinations reflects their grouping into word units, much the way texts do in English. To assess the manipulation of this variable in terms of foreign language reading behavior and development, this experiment will measure eye movement parameters of native Chinese readers, as well as those of non-native readers who represent different Chinese language proficiency levels.

#### Eye Tracking Research

Ever since Chavall observed in 1850 that a reader's eyes do not glide across a printed page but instead make rapid, staccato-like movements, researchers have investigated whether the examination of eye movement behavior could lend insight into the reading process. Much of the seminal research done in eye movement research has attempted to quantify and qualify temporal decision measures, such as when the eyes are moved, and spatial decision measures, such as where the eyes are projected to during the "jump," or saccade.

It is commonly agreed that the only time the eye can acquire information for reading is when it fixates the printed page because during the saccade, visual acuity is so suppressed as to be useless for reading (Wolverton, 1979, cited in McConkie, 1983). Researchers have generally found that in the silent reading of an English text by adult readers, the average fixation duration between saccades is approximately 200 to 260 msec (Levy-Schoen & O'Regan, 1979). Although fixation duration has been considered to be a rough index of processing time for the information currently fixated, there is still lively debate concerning the chronology of perceptual and processing events as derived from eye movement measurement. Researchers such as Just and Carpenter (1980), for instance, claim that a saccade is not programmed until the currently fixated information is completely processed; others (Hogaboam & McConkie, 1981) theorize that the processing of previously fixated areas may continue into subsequent fixations.

Saccade amplitude, or the length of the eyes' jump between fixations, is approximately eight character spaces when the eyes move to the right, and four to five when moving backwards to the left in a regressive fixation. Although early theory regarding saccadic movement stated that the eyes were programmed to perform somewhat random patterns of movement (Kolars, 1976), an increasingly large body of evidence suggests that eye movement guidance may be controlled by cognitive processes as well as visual information derived from the

text (Hochberg, 1970; McClelland & O'Regan, 1981; McConkie, 1979; O'Regan, 1979; Rayner, 1979). When individual reader differences are taken into account, it appears that the number of regressive fixations is the most variable. Mean saccadic amplitude varies less, while mean fixation duration seems the least variable (Levy-Schoen & O'Regan, 1979).

Before the advent of more sophisticated measurement equipment, the rough index of the amount of information acquired during a fixation was to simply divide the number of fixations by the number of words read in a text. Yet, such an index tends to underestimate the total potential of the visual system in acquiring information during a fixation by emphasizing the role of the fovea, the area of the retina encompassing two degrees of visual angle that provides the highest degree of visual resolution. McConkie and Rayner (1975), through the use of more sophisticated computer-based systems, have studied broader areas of visual acquisition in order to define a "perceptual span," defined by McConkie (1983) as "that region around the center of vision within which some aspect of visual detail of interest is used in reading (or affects the reading process)" (p. 81).

A summary of their research (Rayner, 1983) concludes that for readers of English, the perceptual span is asymmetrical, extending "from the beginning of the currently fixated word (but not more than three or four characters to the left of fixation) to about 15 characters to the right of fixation" (p. 97). Rayner states that

information useful for word identification falls within the foveal and parafoveal region, while information such as word shape and specific letter identification are acquired slightly further to the right. Less specific information lending clues as to word length seems to be acquired out to about 15 characters to the right of fixation.

### Theoretical Bases

Research into the limits of the perceptual span suggests that different areas of the visual field may provide different yet complementary types of information during the reading process. The role of peripheral vision during reading has received special emphasis from researchers, so much so that its role has been theoretically delineated by Hochberg (1970; 1976) and later expanded by Fisher (1979) to support and compliment the LaBerge and Samuels (1974) model of reading.

Hochberg (1970; 1976) posits a two-fold model of reading claiming that the eyes of a skilled reader are guided by what is termed "cognitive search guidance" (CSG) and "peripheral search guidance" (PSG). CSG includes factors such as language constraints that heighten the readers "guessing ability" at how much further along in the text he/she should look next in order to test hypotheses and formulate new ones. The reader uses PSG to prescreen information such as word shape and gross word length gained in peripheral vision; this information interacts with linguistic expectancies to select the

places where the reader should seek successive stimulus input, and as CSG increasingly integrates and extracts more meaning, PSG is free to interrogate larger units of text. This model is interactive in that CSG provides PSG with global information about what cues are to be expected. PSC is then sensitized to those cues, so that when they are located and detected, eye movements bring the cues into high acuity regions for more in-depth analysis and perhaps integration across a number of fixations (Fisher, 1976).

Research investigating developmental reading behaviors (Fisher & Lefton, 1976; Fisher & Montanary, 1977; Spragins, 1974; Spragins, Lefton, & Fisher, 1976) has led Fisher (1979) to conclude that this dependence upon peripheral vision increases with age and reading ability. He interprets the developmental reading data as showing that when word boundary cues are mutilated in the text, the reading process of more experienced readers is disrupted because they process larger units of information that require word boundary differentiation; younger children, however, are not hampered by the lack of boundary cues because they read using a letter-by-letter or word-by-word processing strategy. In other words, they manifest a "tunnel vision" strategy through dependence upon foveal processing with no reliance upon the periphery.

When viewed in terms of the Hochberg (1970; 1976) model, Fisher (1979) concludes that in younger readers, PSG is all but rendered dysfunctional, but that dependence upon, as well as increasing



facility with perceptual extraction will increase the role of PSG as readers gain experience. Fisher considers the developmental roles of PSG and CSG to be consistent with the model of reading put forth by LaBerge and Samuels (1974).

Laberge and Samuels (1974) posit a stage analysis model of reading beginning with the decoding of graphemic information, and ending with an interpretation of the contextual material. These stages go from detecting letter features, to letter codes, to spelling pattern analyses, and eventually to a visual word-code analysis. To accomplish these various tasks, the reader has only a finite amount of "attention" to allocate between decoding and comprehending. Consequently, beginning readers often "attention switch," meaning that they process text by the slow and laborious process of switching off between decoding and comprehending. According to this model, attention switching is inefficient because the attention devoted to decoding interferes with and disrupts the process of coherent message building performed by the higher order comprehension processes.

The skilled reader, on the other hand, has, depending upon the nature of the reading task, largely reached the stage of "automaticity" in processing text; that is, the lower level processing required for graphemic decoding is performed automatically, thus freeing attention for the organization of meaning codes in semantic memory. Originally conceived as a linear, bottom-up model, Samuels (1977) added feedback loops from semantic memory in this model to

account for the reader's particular background, knowledge of the content area, and knowledge of the orthography and language in general that the reader brings with him/her to the reading experience so that prediction in reading can be facilitated.

Fisher (1979) integrates the Hochberg (1970; 1976) dichotomy of CSG/PSG into this model. When the printed page is fixated, Fisher believes that the visual and phonological memory systems activate the CSG which establishes basic meaning and provides PSG with clues as to the word shape and word length information it may encounter further down the line. In terms of the concept of automaticity as put forth by LaBerge and Samuels (1974), Fisher believes that the developing reader's increasing use of PSG signifies a concomitant ability to "direct attention away from graphemic codes and, consequently, deal with larger portions of text, facilitating automaticity still further" (1976, p. 121). With increased exposure to reading, the preprocessing of peripheral areas that aids hypothesis testing and prediction receives the attention that is directed to decoding and foveal processing by less mature readers.

Evidence from developmental studies suggests that the decoding abilities of fifth- and sixth-grade children approximate those of adults (Singer, 1972, as cited in Fisher, 1979). In terms of reading development, it seems that most of the effort for children prior to this time is spent on learning to decode the text, but as skill develops, an increasing dependence upon peripheral retinal processing

becomes apparent as the reader dedicates effort to comprehension. As the amount of language skill increases, reading can proceed further into the periphery because the amount of visual detail needed by the reader is not as great, resulting in lengthened saccades (McConkie, 1979).

Such a theory of reading is also consistent with the views of other research scientists who view perceptual development as a key factor in the reading process. Gibson and Levin (1975), for instance, state that as perceptual development and exposure to the printed page increase, readers manifest a more economical pickup of information, an increased specificity as to the information attended to, as well as more economical allocation of attention. Gibson and Levin further claim that these more advanced strategies are disrupted when the beginning reader allots most of his/her effort to "decoding," a term used to signify "the 'mechanics' of reading that implicate attention to graphic and orthographic information, translation to speech sounds (whether vocal or subvocal), and moving the eyes over the text in the correct path" (p. 378). Such behaviors, when not fluid and automatic, disrupt the reading process in that attention can not be allocated for meaning extraction. When attention is freed from the decoding process, readers can then concentrate upon processing increasingly larger structural units for meaning.

### Theoretical Bases: L2

The role of text-based features in second language reading models has also received recent emphasis. To account for the factors in reading that are both text-based and extra-text based in nature, Bernhardt (1986) has developed a constructivist model of reading based upon recall-protocol measures derived from L2 learners of German and Spanish (Bernhardt, 1983; 1985a; 1985b). This model posits an interaction between certain text-based components such as word recognition, phonemic/graphic decoding, and syntactic feature recognition, and extratext-based components such as intratextual perception, prior knowledge, and metacognition. Because the interaction of these components is dynamic and non-linear, this model states that combinations of these components interact with and influence other components.

Such a model is valuable in that it more economically represents the global theory of L2 reading which states that L2 reading difficulties arise from the learners' imperfect knowledge of the target language (Clarke, 1979; 1980; Cziko, 1978; Yorio, 1971). In essence, it recognizes that potential breakdowns due to imperfect knowledge of the language can occur, yet the more significant implication of the Bernhardt (1986) model is that the facilitative effects of text-based and extratext-based components may differ from language to language. Such a model, when viewed in terms of the present study, leaves open the possibility that the unique nature of

the Chinese orthographic display may interact with the student's language ability to affect the reading task. Said another way, this model accounts for the problems encountered by the non-native reader of Chinese in that he/she is faced not only with a language problem, but also with the demands inherent in coping with a different orthography.

Empirical studies dealing with the effects of orthography upon foreign language learners have only recently been attempted. Investigations into French (Sacco, 1984) and German (Bernhardt, 1985a; 1985b) have revealed that the orthographies of these languages do not present significant problems for American learners. In fact, the latter study suggests that experienced non-native readers of German show signs of exhibiting native-like behaviors in their reading. The behaviors of these advanced and successful readers of German seem to support Alderson's (1984) hypothesis that "poor foreign language reading is due to incorrect strategies for reading that foreign language, strategies which differ from the strategies for reading the native language" (p. 4). Yet, if we are going to explain such strategies with any significant degree of meaningfulness, such an assertion needs to be tested among foreign language students learning different orthographies.

### Significance of the Problem

Although this study investigates only one small factor involved in the learning of Chinese as a foreign language, its findings may generate useful hypotheses concerning cross-orthographic reading processes. The theoretical bases presented thus far and the empirical evidence to be presented in the second chapter of this study strongly suggest that the spacing of English words in printed material serves to facilitate featural identification and word-length prescreening in peripheral vision, which in turn serves to guide the eyes for more efficient informational acquisition. Yet, one may question the goodness of the theoretical fit when applying these models to the Chinese language.

Studies involving native Chinese readers, for instance, have shown that the informational intake as revealed by their fixation frequencies is smaller when compared to the usual standards of English readers reading their native language (Miles & Shen, 1925; Shen, 1927). Wang (1935) hypothesizes that this may be due to the uniform amount of space taken up by each Chinese character regardless of its stroke density. Woodworth (1938) believes this uniformity may render Chinese characters more adaptable to foveal viewing than English words having more variable shape and length. Peng, Orchard, and Stern (1983) and Stern (1978) have also documented that native readers of Chinese make more saccades per line when reading English than do Americans when reading the same text. One of their hypotheses is that

the "perceptual habits" of these readers may be transferred to the reading of English.

The theoretical bases provided by Hochberg (1970, 1976) and Fisher (1979) might explain this problem as being due to the Chinese readers' imperfect knowledge of the language that impacted upon their CSG. Because these data show that the Chinese subjects read English text at about half the rate of the American subjects, it also could be hypothesized that an emphasis upon decoding the fixated words militated against the preprocessing of peripherally viewed words carried out by PSG.

One of the more intriguing questions asked by this study is how this process will work when the roles are switched, that is, when American readers of varying Chinese reading ability read a Chinese text. The data provided by Peng, et al. (1933) and Stern (1978) indicate that Chinese readers bring their perceptual reading strategies with them when reading English. The question of interest then becomes whether the American subjects will transfer their habits of taking in broader areas of information when reading Chinese texts, or will the nature of the orthography and the typographical layout, combined with their imperfect knowledge of the language, dictate sampling habits of a more conservative nature. Clearly, one study will not serve to answer all of these questions; yet, the overriding significance of this study is that it will provide global eye tracking data from which to test the explanatory power of our reading theories

when applied to cross-orthographic situations. As Hung and Tzeng (1981) have so cogently noted, "insofar as the logographic, syllabic, and alphabetic scripts map onto their respective spoken languages at different levels...it is important to know whether these orthographic variations affect eye fixation and eye scanning patterns during reading" (p. 386).

When viewed from a pedagogical perspective, this study can begin to answer questions concerning some of the practices currently employed in Chinese reading materials. Certain reading texts, for instance, artificially space the characters into units corresponding to English words, presumably to facilitate the "chunking" of individual characters into word units. One of the questions this study will attempt to address is the efficacy of such a methodology.

#### Purpose of the Study

Stated in terms of a research question, the present study asks:

Will artificially spacing a Chinese text so that word-unit boundaries are clearly demarcated affect the reading behaviors of native as well as non-native readers of Chinese who are at different proficiency levels, as measured by indices of fixation duration, fixation frequency, regressive fixations, reading rate, and reading comprehension?



In addition to answering the main research question, the study will also:

Provide baseline data documenting the reading behaviors of native and non-native readers of Chinese as measured through the tracking of their eye movements. Such a study contributes to the dismayingly small collection of eye tracking studies involving native readers of Chinese and sets the precedent of being the first study involving readers learning Chinese as a foreign language;

Document the development of reading skills through quantitative analysis of the differences exhibited by non-native learners of Chinese at various developmental stages as measured through the selected dependent variables mentioned above.

#### Definition of Terms

The following terms as used in this study are defined as follows:

1. Non-native: a learner of Chinese whose native language is English.
2. Word-unit: a single character or combination of characters that has been spaced apart from other characters in the "artificially spaced" reading stimulus. Certain character compounds in Chinese, such as bi-morphemic nouns, lend themselves quite readily to being spaced together due to their translational equivalence with English (Chao, 1968, p. 184). Because of the unique syntactic nature of the Chinese language, however, the overriding concern in this study was to space certain characters together to show that each was an integral part of

a larger Chinese word-unit. For instance, the character combination 吃完了 (*chīwánle*: eat-finish-particle: "finished eating") was spaced together to reflect its integrity as a verbal word-unit, although spacing the characters in the following fashion, 吃 完了 , would be more consistent with its literal English equivalent of "finished eating." In addition to the rationale cited above, this decision was reached because when students learn to read Chinese via romanization (i.e. through the use of Chinese sounds represented in English orthography), beginning reading texts preserve this larger word-unit integrity.

## CHAPTER II

### REVIEW OF THE LITERATURE

#### Global Eye Tracking Indices

Ever since Chavall discovered in 1850 that a reader's eyes do not "glide" across the printed page, but instead travel in short, staccato-like movements, psychologists have regarded the patterns of readers' eye movements as a potential source of data for understanding the reading process. In spite of ingenious but primitive data collection equipment, by the beginning of the 20th century many global eye movement indices exemplifying the behaviors of good and poor readers had been established by European and American psychologists that are still valid today (Huey, 1908/1965).

Foremost among the American psychologists involved in eye tracking research was G. T. Buswell who performed exhaustive data-based studies that investigated the development of reading skills in children (Buswell, 1922) and the reading behaviors of good and poor adult readers (Buswell, 1937). Interpreting eye movements as "symptoms of the process used in reading" (Buswell, 1937, p. 8), Buswell noted that certain eye movement parameters showed consistent developmental trends. First, decreases in fixation frequency,

fixation duration, and regressive fixations were noted during the first four years of school, followed by a plateau extending until the freshman year of high school for fixation frequency and regressive fixations, and the junior year for fixation duration. A second decrease occurred during the high school years. Buswell attributes these developmental changes to the many and varied tasks inherent in the school curriculum, including change in content subjects, change in reading purpose, and new study habits.

Buswell's (1937) findings with adult subjects also showed that more mature adult readers make fewer eye fixations per line and fewer regressive fixations. Although a less variable index, Buswell also found that mature readers perform generally shorter fixation durations. Better readers also have more rhythmic eye movements as their eyes move over the text, while poorer readers tend to be erratic, allocating their fixations in an uneven manner. Buswell found that these indices are variable depending upon the difficulty of the textual material and that better readers are more flexible in adjusting their reading behaviors as indicated by their eye movements. Poorer readers, on the other hand, are not.

Similar findings are put forth by Lefton, Nagle, Johnson, and Fisher (1979) who measured the eye movements of poor fifth-grade readers, proficient third- and fifth-grade readers, and those of adults. Their results suggest that poor fifth-grade readers are similar to normal third-grade readers in their performance in terms of

fixation frequency, duration, and frequency of regressive fixations, but perform worse than the third-graders in many cases; also, over one year's time between reading the same text, the third- and fifth-graders improved markedly, whereas the improvement for poor readers was minimal. The most noteworthy finding of the study, however, is the within-group variability of the eye movement behavior of the poor readers.

Although adults were far less variable than the children, the within-group variability of the poor readers was high, displaying an erratic, unsystematic fixation strategy that differed in fixation frequency and regressive fixation from line to line, similar to the behaviors reported by Buswell (1937). Lefton, et al. (1979) hypothesize that this unsystematic fixation strategy adds to the burden of information gathering and processing, and disrupts the role of peripheral vision in directing subsequent eye movements.

#### The Perceptual Span and the Role of Spacing

The role of peripheral vision in abstracting information necessary for reading has recently come under scrutiny by a number of reading psychologists. While scientists have long been interested in how much can be seen during one fixation while reading, researchers (McConkie & Rayner, 1975; Rayner, 1975) have hypothesized that this question is oversimplified, as different types of visual information might be available to the reader from different areas in the retinal

field. To examine the length of this span as well as its different areas, investigators have developed computerized methods of textual presentation that can control and manipulate the text to be viewed in different areas of the subject's visual field.

Rayner and Bertera (1979), for example, studied the effects of masking the foveal region of readers (approximately two degrees of visual angle across the fixation point) in order to determine the extent to which readers use extrafoveal viewing to identify the meanings of words. To accomplish this, subjects were required to report what they had read from a CRT display that masked foveal vision to varying degrees and that moved in synchrony with the readers' eye movements.

The researchers found that the correct reporting of words decreased dramatically as the size of the mask increased. When the foveal area was completely masked, the types of errors made indicates that the readers were only obtaining information about beginning and sometimes ending letters of words in parafoveal vision, while word shape and word length information also seemed to be available. This substantiates the claim that information needed for the semantic identification of words is obtained from the foveal and near parafoveal region, whereas less precise information is obtained from the parafovea.

A similar experiment conducted by Rayner, Inhoff, Morrison, Slowiaczek, and Bertera (1981) reveals similar characteristics of foveal and parafoveal reading as well as the disruptive effects to reading rate when the foveal region is increasingly masked. When only one character was masked in the foveal region, reading rate dropped from 295 wpm to 160 wpm. Errors reported by the readers tended again to reflect visual as opposed to semantic similarity, thus implying that the parafoveal region provides clues to specific letter information and word length.

Rayner (1975) employed a computerized display technique designed to investigate inconsistencies between what the reader views in peripheral vision and what is viewed when the reader centrally fixates this portion of text after a saccade. To accomplish this, a CRT display was programmed so that when the reader's eyes crossed a predetermined boundary in a paragraph, one word viewed within the subject's periphery was replaced with a word or letter string that did or did not maintain certain visual or semantic characteristics of the word or letter string viewed when it appeared in the periphery.

Rayner (1975) manipulated the base words so that some maintained the syntactic/semantic flow of the sentence, while non-word string replacements preserved expected word shape to varying degrees. By also modifying the distances into the periphery where the words were replaced, Rayner was able to determine how far into the periphery certain types of information would be detected and thus acquired for

reading. Because the information gathered from the periphery would conflict with the information when it was viewed from central vision on the next fixation, an increased fixation duration was expected and measured as the dependent variable.

Rayner's (1975) results demonstrated that when the reader fixated 1 to 6 character spaces prior to the location of the base word, he/she was able to make a semantic interpretation of the word. If the reader was fixated 7-12 letters from the base word, word shape as well as initial and final letter detection was possible. Rayner concludes that semantic interpretation and word/non-word distinction can be made only in the area of high visual acuity, or about two degrees of visual angle. Word shape and letter information seem to be gathered at about five degrees of visual angle to the right of the fixation point.

McConkie and Rayner (1975) refined and expanded this paradigm through a computerized display that manipulated the type of information viewed in peripheral vision as well as the amount. The computerized textual display was designed so that when the subject fixated a line of text on the CRT, a certain region to the left and right of the fixated position contained unmodified text so that it appeared "normal" to the viewer, thus creating a "window" for normal reading. The text in the periphery, however, was mutilated in certain ways so that peripheral vision was impoverished to varying degrees. When the reader initiated a saccade to continue reading, however, the computer modified the display so that the newly fixated area was



presented in normal text, while the previously fixated area was changed to reflect the mutilated condition. In short, wherever the reader looked, normal text would appear so that reading could continue normally, while only areas in the periphery would be perturbed. The value of this paradigm is that McConkie and Rayner could both determine and manipulate the size of the window displaying normal text, as well as vary the nature of the pattern in peripheral vision.

To conduct the experiment, McConkie and Rayner (1975) had six high school students purported to be among the best readers in their school read various 500-word paragraphs using different window sizes and peripheral patterns. Their results show that when word length is eliminated due to the absence of spaces between words in the peripheral test pattern, the readers' saccades tend to be shorter. The difference between the spaced and filled-in versions of the text was present up to window size 25 (i.e. 12 spaces either side of the fixated point), leading the researchers to conclude that "word-length pattern information is acquired at least as far as 12 character positions (three degrees) from the center of vision, and perhaps even farther, and may be used in guiding the eye during reading" (p. 582).

Fixation duration and regressive fixations, however, seemed to be more influenced by letter replacement. Letter replacement in one condition was accomplished by placing letters in the periphery that were visually similar to the letters that would appear when the word was actually fixated by the reader; in another condition, words made

up of letters with different ascending and descending features than those to be centrally fixated were placed in the periphery. The difference between these conditions led to a small difference in fixation duration at the two smallest window sizes, but this difference disappeared at window size 21. Thus, at the smaller window sizes, fixation duration seems to be increased through improper word shape pattern, but word-shape information does not seem to be acquired as much as 10 character positions from the point of fixation.

McConkie and Rayner (1975) concluded that specific letter and general word shape information is acquired no more than 10 or 11 character positions (two and a half degrees) from the point of fixation and that "word-shape patterns, other than word-length characteristics, appear to be acquired no further into the periphery than is specific visual information needed to identify letters" (p. 583). Rayner and Bertera (1979) found that when the window size was increased to 29 (i.e., 14 character spaces either side of the fixated point), reading performance was similar to when the entire line was visible in the periphery, thus lending support to McConkie and Rayner's conclusion that the field of useful vision during fixation is about 12 to 15 characters to the right of fixation.

It was also found that the time required to read the text was affected by window size, resulting from the reader making more fixations of longer durations as window size decreased. Window size shrinkage, however, did not affect the number of regressive eye

movements, nor did it affect scores of reading comprehension.

Similar results were found in other experiments increasing the amount of the window size available to readers. Rayner, et al. (1981) showed readers sentences on the CRT that the subjects were required to repeat to the experimenter after reading. Reading performance improved as the window size increased, with the size 29 and 33 reflecting the same performance as when the entire line was visible. Fixation duration decreased with increasing window size up to window sizes of nine characters or more, beyond which fixation duration did not differ. Saccade length, however, continued to increase up to a window size of 29 characters, leading the researchers to conclude that information used in eye movement guidance is obtained from a distance twice that of the average saccade length, implying an overlap of information gathered over successive saccades.

In an experiment using paragraphs in Japanese, Ikeda and Saida (1976) also employed a window technique for measuring the span of recognition among readers. In this experiment, only the window sizes were manipulated so that varying amounts of text printed in horizontal fashion were available, while the text outside these windows was not available for peripheral viewing. Window sizes varied from 2 to 20 degrees of visual angle, corresponding to 2.6 to 26.3 letter spaces respectively.

Their results show that as the size of the visual field is decreased from eight to two degrees of visual angle, reading rate slows and saccades become relatively small. With an increase of visual angle from 8 to 20 degrees, there is no significant alteration in saccade span. The authors conclude that the critical visual field size, or the size of the field beyond which there is no increase in reading rate, ranges among different readers from between 10 to 17 letters. Because the mean saccade size was only 2 to 5 letters even when the largest window sizes were employed, Ikeda and Saida conclude as did Rayner, et al. (1981) that information acquisition is done in an overlapping and redundant fashion, indicating "some kind of pre-processing of information at the peripheral visual field, which eventually minimizes the pause duration at every fixation" (p. 87).

#### Developmental Trends

Although this line of research used to determine the perceptual span in reading has been valuable in defining the limits of the availability and types of information used in reading, research conducted among readers at various stages of reading competence suggests that the increasingly effective use of peripheral vision in reading may be developmental in nature.

Hochberg, Levin, and Frail (1966, cited in Hochberg, 1970), for example, prepared short stories in two typographical versions. One was a normal version, while the other had the spaces between words

filled with a meaningless typographical symbol. When viewed in peripheral vision, the latter version looked like an unbroken line of type. Stories presented in these two typographical conditions were administered to good and poor readers in first-, second-, fifth-, and sixth-grades, with their reading rate subsequently measured. The results showed that the filled-in version took significantly longer to read, but that the poorer readers showed little drop in reading rate induced by this condition; better readers, on the other hand, suffered more of a loss in reading rate.

Fisher (1975) extended this line of research by testing the effects of spacing when used in conjunction with manipulated letter case. Fisher manipulated the spacing variable by spacing some paragraphs normally, by using no between-word spacing at all, or by filling the spaces with either +'s or @'s depending upon whether the text employed upper- or lowercase letters. The letter case variable was manipulated by having some paragraphs written normally, some written entirely in uppercase letters, and still others with letters that alternated upper- and lowercase. Combined factorially with the spacing manipulations, a total of nine possible conditions were used. The dependent variables in this study were reading rate and reading comprehension.

Fisher's (1975) results show that reading rate suffers due to word shape and boundary perturbation. When word shape was degraded, adults read at a rate approximately 10-15% slower than normal; when

word boundaries were degraded through spacial variation, reading rate was reduced by 50%. The greatest reduction in reading rate, however, was between the two most extreme conditions, that is, between normal text and the text where letter case was altered and spaces between words were deleted. Between these two conditions, reading rate decreased from 220 wpm to 70 wpm. Comprehension, however, reached significance only for type variation and not spacing.

Fisher and Lefton (1976) performed a similar experiment involving third-, fourth-, and sixth-grade readers as well as adults. Again, the slight variations in comprehension measures between groups was interpreted to mean that subjects sacrifice little in terms of comprehension with changes in word boundary. Like the Fisher (1975) study, however, reading rate decreased from the normal, uppercase, and alternating case conditions, respectively. Similarly, as word boundary clues were eliminated or altered, reading rate decreased from the normal, filled, and absent conditions, respectively. Significant interactions demonstrated that extraction of the word shape clues is dependent upon the availability of word boundary cues; also, the effect of these cues varies with grade, while word shape and word boundary cues become more important with increasing reading proficiency.

A similar experiment (Spragins, Lefton, & Fisher, 1976) involving adults and third- and fifth-grade children indicates that reading speed is reduced for all ages when word shape is distorted. Their

data suggest that word shape as a cue was dependent upon the available word boundaries while alternating case brought a substantial decrease in reading speed when word spacing cues were destroyed for the adults and third graders, but that these effects did not seem very dramatic for the fifth graders.

Although these data are taken as evidence that adults use peripheral cues more effectively than children, Stewart-Lester and Lefton (1981) hypothesize that these differences may stem from the child's inability to process information as quickly and are not due to an age-related difference in their ability to make use of peripheral information. To test their hypothesis, the researchers presented adults and third- and fifth-graders with normal and alternating case words displayed tachistoscopically to either the foveal or parafoveal regions of visual acuity. To equate the difficulty across the different age groups, visual noise masking procedures were used to control processing time.

Stewart-Lester and Lefton's (1981) letter recognition results showed that when processing time is controlled, there is little difference between grade levels in the ability to extract parafoveal information. The researchers conclude that since their task involved word recognition devoid of peripheral cues used in normal reading, the age-related differences demonstrated in normal reading may be attributable primarily to cognitive use of peripheral information. Because their data show no differences in age-related peripheral

information extraction capability, the role of CSG in adult use of linguistic cues to anticipate and predict what will come next may play a larger role in the reading process than was originally thought.

The effects of different types of spatial transformations has also been measured through the use of eye tracking procedures. Fisher (1976), for instance, found that between the most normal and transformed conditions used in his experiments, i.e., normal case/normal space and alternating case/no space, reading speed decreases to about one-third normal rate, while fixation frequency increases with the increasing spatial complexity. The perceptual span as measured in character spaces per fixation also decreases with spatial cue perturbation.

Perturbing the text also seems to affect eye movement behaviors of adult, third-, and fifth-grade subjects as reported by Spragins, et al. (1976). In their experiment, the fixation duration means for the filled in/absent space condition did not differ from each other, yet were different from the normally-spaced condition. Fixation duration generally decreased with grade. The third- and fifth-graders, however, showed no difference in fixation duration between alternating and normal case, yet there was a difference between these conditions in adults. When word shape was distorted, adults increased their fixation duration 25%; the fifth-graders fixation duration increased only slightly, while that of the third-graders actually decreased.



The third- and fifth-graders were significantly different from adults as measured by the occurrence of regressive fixations. The total percentage of regressive fixations was affected by word shape distortions differently at each grade level. Fifth-graders had the high percentage of regressions for normal case while adults had a high percentage of regressions for alternating case.

Spragins (1974, as cited by Fisher, 1976) also examined the eye movements of third-graders and adults under conditions of normal case and space, and alternating case with no spacing. Under normal conditions, her data showed that adults read twice as fast (130 vs. 260 wpm), but under the most perturbed conditions, reading rate for adults dropped to 60 wpm for the adults and 50 wpm for children. The actual decrement of decreasing efficiency is much higher for adults than third-graders in measurements of spaces per fixation and fixation duration. Between the two conditions, third-graders went from 184 fixations per minute to 181 while adults went from 209 to 172. Measures of fixation duration between the two conditions went from 400 to 393 msec in third-graders, but from 235 to 365 msec in adults. Regressive fixations were not affected by case, space, or grade level.

In order to further this line of inquiry to include textual difficulty, Fisher and Montanary (1977) investigated the behaviors of second- and fifth-grade subjects reading aloud spacially transformed text of their own and the other subjects' level. In one experiment, each student read four paragraphs at his/her own grade level of

difficulty, two of which were normally spaced and two of which had +'s between the words. Significant main effects showed that the fifth graders read faster than second graders, and that normal type was read faster than filled type. Unexpectedly, however, the group by space interaction was not significant, indicating that both groups were equally disrupted by the filled space condition.

In another experiment, second- and fifth-graders each read second- and fifth-grade level paragraphs that were either normally spaced, or had the spaces between words filled in. As expected, the fifth-graders read faster than the second-graders, and normally spaced paragraphs were read faster than the paragraphs where the spaces were filled in. Significant interactions indicated that both groups read the normal second-grade paragraphs fastest, and that when reading the filled-in second-grade and normally-spaced fifth-grade paragraphs, the reading rate was slower, but equivalent between groups. The reading rate of the fifth-graders reading the filled-in fifth-grade level paragraphs was reduced to that of the second-graders reading normally spaced second-grade level paragraphs. Yet, only a smaller reduction in speed was noticed between the filled-in fifth-grade paragraphs and the normally-spaced fifth-grade paragraphs. Analysis of main effects seemed to indicate a tradeoff between difficulty and spatial information.

Fisher (1977) interprets these data as showing that the fifth-grade readers could easily read the normal second-grade passages, thus freeing more peripheral processing of the text. Moreover, reductions in reading speed also occurred when the text became more difficult and when the reading level stayed the same, but the spacial aspect was degraded; that is, both manipulations had the effect of producing a "tunnel-vision" effect. Fisher concludes that as the fifth-graders read from the easiest to the most difficult and progressively more degraded paragraphs, the increasingly restricted functional field of view dictates strategies requiring letter and word processing, thus producing a failure of automaticity and a lowering of the fifth-grade performance to that of second-graders. Fisher also notes that second-graders displayed similar trends, though the magnitude of the differences between stages was not as great.

Pollatsek and Rayner (1982), however, present evidence showing that when sentences with only certain between-word spaces are filled in, differential effects will be noted. In one experiment, a CRT was programmed to substitute certain between-word spacing conditions contingent upon the reader's eye fixation. These three conditions included filling all of the spaces viewed to the right of the reader's fixation, all spaces viewed to the right except the first space, or only the first space to the right of the viewer's fixation. The researchers found that when the space immediately to the right of the fixated word is filled in, reading is more impaired than when it is

not. They conclude that most of the decrement in reading resulting from space filling seems to be due to filling the space to the right of the fixated word, possibly due to disrupting the identification of the fixated word itself; while there is a disruptive effect from filling in the spaces viewed in parafoveal vision, this effect seems to be of lesser consequence.

#### Summary

Recent perceptual span research has been useful in delineating the roles of different areas in the retinal field responsible for the various types of informational acquisition performed while reading. This research has demonstrated that the area of visual acuity used for reading is quite small, extending in English to about 15 characters to the right of fixation. This area of 15 character spaces, however, contains information used for different purposes. It seems, for instance, that information useful for word identification is gained from the foveal and near parafoveal region, while information useful for determining word shape and word length are acquired further to the right.

Research has also shown that manipulating word boundary and word shape information in the periphery has the effect of disrupting the reading rate in adults, in addition to affecting eye movement behaviors. Although there is a definite disruptive effect when

manipulating the entire peripheral array available to the reader, it has been suggested that much of the disruption stems from modifying the spacing next to the word currently fixated.

Much of the resultant loss in reading efficiency due to the effects of peripheral manipulation, however, seems to be greater among adult readers. This evidence has been interpreted to mean that effective use of the periphery in reading is developmental in nature, and that less experienced readers are not as greatly affected by peripheral cue manipulation because they do not as yet make use of these cues so critical for pre-screening and hypothesis testing. Experienced readers, on the other hand, compensate for the lack of peripheral cues by going from a large unit processing strategy to one employing a nearly letter-by-letter analysis, thus demonstrating that adults are able to fall back upon elemental reading strategies to cope with the demands of typographical perturbation. This strategy switch is reflected in measurements of reading rate and certain eye tracking behaviors, but does not seem to affect comprehension.

Unfortunately, little is known about the effects of peripheral manipulation upon the reading behaviors of subjects reading in Chinese or in other foreign languages. There is, however, a small body of evidence dealing with the reading of languages other than English that provides certain insights into the behaviors of native readers, as well as non-native learners possessing varying degrees of reading proficiency in these languages.

### Eye Tracking Studies Involving Readers of Chinese

Researchers have for decades employed eye movement tracking procedures in an attempt to understand more fully how native Chinese readers process text. It was, for instance, included in a 14 language study commissioned by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in 1953 to identify global behaviors in the reading process that could be generalized across cultures (Gray, 1969). Through the use of eye tracking procedures, the study concluded that oral and silent reading behaviors as measured by indices of eye fixations are essentially the same among all mature readers of these languages.

Miles and Shen (1925) were among the first to analyze eye movements to generate hypotheses concerning the reading of Chinese by Chinese natives. They concluded that the perceptual span may be different for English and Chinese, and generated initial hypotheses concerning the merits of horizontal vs. vertical character layout. Shen (1927) continued this line of inquiry, concluding that the fixation duration in horizontal reading is shorter than in vertical reading, but that the span in vertical reading is larger, thus resulting in faster reading using this format. Wang (1935) examined the eye movements of Chinese subjects reading the same texts written in classical and vernacular Chinese while also investigating "careful" versus "rapid" means of reading. His results confirmed earlier

hypotheses (Buswell, 1937) that mature readers are flexible and that they adjust their processing to the text and task demands. Wang also hypothesized that the span of recognition in reading Chinese is, on the whole, larger than that employed in the reading of English.

In a pilot study conducted by Stern (1978), the eye movements of native Chinese who had 7 to 14 years of experience with the English language were investigated while reading a Chinese and English text. Despite the fact that the width of text was identical, information content was more dense in each Chinese line due to the economical nature of the characters. Yet, the incidence of saccades was large (averaging about 10 saccades per line) in reading either the English or Chinese passages. In reading the same passages, native speakers of English averaged approximately four saccades per line, while there was no difference between groups in measures of fixation duration; the difficulty of reading English seemed to be manifested by the Chinese readers in making more regressive fixations than their American counterparts. Stern concludes that Chinese readers of English seem to bring the strategies that made them proficient readers of Chinese to the reading of English, a strategy that results in the inefficient reading of English. This position argues for the persistence of reading style, though the design of this study could not determine whether this "style" is trainable.

In a somewhat similar cross-orthographic experiment, Sun, Morita, and Stark (1985) translated English scientific articles into Chinese and compared the eye movements of subjects reading these articles in their native languages. Similar to the Stern (1978) findings, fixation duration was similar in the reading behaviors of both language groups. Sun et. al, however, measured the lengths of the number of English words and Chinese characters in the respective texts and found that the average English word was equivalent to approximately 1.5 Chinese characters. Based upon this equivalent word factor, they discovered that the forward saccade was very similar for both groups, measuring 1.7 Chinese equivalent words for Chinese readers and approximately 1.8 English words for the American subjects. One of the more provocative observations that concerns the present study is their mention of qualitative evidence indicating that the Chinese subjects usually fixated once per multicharacter word.

In a study chiefly designed to investigate the eye movement patterns of American and Chinese readers reading the same text that was translated into their respective languages, Peng et. al (1983) also investigated the reading behaviors of Chinese subjects reading English texts. They found that all eye movement indices were affected by the language switch--more regressive fixations, longer fixation duration, greater fixation frequency, and fewer lines without regressions were all noted. Thus, it remains to be investigated whether these behaviors are due to perceptual habits of Chinese in



taking in smaller amounts of information, or whether this phenomenon can be attributed to their insufficient knowledge of the language.

#### Foreign Language Eye Tracking Studies

Investigation into the foreign language reading process began in America more than 50 years ago when Buswell (1927) expanded his eye movement research to include a series of experiments involving French, German, Latin, and Spanish foreign language students. Buswell's study is of historical interest because it attempts to answer certain questions in foreign language education that researchers in the last half-century have continued to investigate with varying degrees of success. Such questions include the optimal age issue, as well as the relative difficulty of learning different languages. It should be pointed out that much of the data reduction in this series of studies is focused on samples taken from the middle half of the classes to derive a "most typical" performance so that much of the subsequent scaling involves comparing mean and/or median performance without the rigor of factorial designs or subsequent post-hoc testing. Buswell himself also notes the problems he experienced with subject mortality. Still, this series of studies is useful in generating global data documenting the development of reading behaviors as measured through selected eye movement indices.

One of Buswell's (1927) experiments, for instance, compared the reading of French texts varying in degrees of difficulty over first- and second-year French students in fourth- and fifth-grades, first- and second-year high school, and first- and second-year college. "Native" readers of French, a category including both native and highly experienced non-native readers, were also compared.

Buswell's (1927) data show that in terms of fixations per line of text, first-year high school students performed fewer fixations than first-year college students, though the second-year high school and college students performed approximately the same. Fixation frequency did decrease, however, between first- and second-year high school students and first- and second-year college students. The number of regressive fixations per line approximated the fixation frequency data, while fixation duration per line was less for the college groups than the high school groups, though the difference was not great.

Data from the elementary students, however, are more difficult to interpret. Although these groups tended to display a more coherent pattern of eye movements over the more difficult text, their comprehension of this text was almost nil; yet, the elementary students showed an increased pattern of fixation frequency and regressive fixations on the easier text. Buswell (1927) interprets these data as indicating that the complexity of the more difficult text was so extreme that the elementary students merely scanned the lines utilizing behaviors carried over from their knowledge of reading

English, and made no attempt at the careful examination necessary for comprehension.

In terms of development as measured by eye tracking indices, Buswell (1927) concludes that there is very little difference between those students beginning their study of foreign language in high school or college, though the rate of progress is much slower in the elementary grades. He also concludes that in no case did a student after two years of study approach the characteristics displayed by mature readers of the language.

Buswell's (1927) research into the comparative behaviors of readers of German, French, Spanish, and Latin led him to conclude that regardless of the structural difference in these languages, the results obtained from two years of study is very similar, and that the process involved in reading these languages is similar. He does hypothesize, however, that because regressive fixations and fixation frequency were higher while reading in Latin than in German, French, or Spanish, the reading of Latin resembles that of the other languages, but seems to be conducted at a more immature reading level.

A study conducted by Oller and Tullius (1973) investigated the eye movements of native and non-natives readers of English. The subjects were blocked according to their native language groups (Indo-European vs. non-Indo-European) and according to how they learned English. Those learning English in a classroom environment within a community where the target language was rarely, if ever,

spoken were termed EFL; those who learned in an environment where the target language was used as the medium of classroom instruction and also by the outside community were termed ESL.

Oller and Tullius (1973) found that the number of fixations between native English readers and non-natives was quite similar, though the ESL group differed significantly from the EFL group in this regard; also, natives had significantly shorter fixation durations than the non-natives, though there was little contrast among the non-native groups themselves. Natives also read more words per minute than non-natives, while ESL students read more words per minute than EFL students.

Interestingly enough, there was no significant difference between native and non-native readers in terms of the number of regressive fixations. The researchers hypothesize that the lack of difference in regressive fixations is due to the fact that the subjects "have already acquired the necessary thoroughness as readers in their own language to enable them to avoid having to reread any more frequently than efficient readers of English who are natives" (p. 78). The fact that the average fixation duration was longer among non-natives is attributed to the short term memory's need for additional time to process the information during the fixation. Conflicting results from the Stern pilot study may be attributable to the fact that there was no dependent measure administered for comprehension in the latter study; also, the only thing clear about Chinese student participation

in the Oller and Tullius (1973) study was that, if it occurred at all, there were no more than one or two subjects.

A study by Bernhardt (1985) employed eye tracking methodologies to determine the effects of reading repetition and varying textual difficulty on the reading behaviors of native and two groups of non-native readers of German. Her results showed that native and experienced readers of German demonstrated a relatively stable pattern of decreasing fixation frequency with repeated reading of the same texts, while inexperienced readers demonstrated irregular fixation frequencies over repeated readings. Fixation duration was also significantly longer for the inexperienced readers than for the experienced groups, although fixation duration across groups decreased significantly from the first to the second reading. The occurrence of regressive fixations was not significantly different among groups. The experienced group also read consistently faster than the inexperienced group, and also displayed more systematically adaptive strategies for reading the difficult text as exemplified by increased reading speed after the first reading; the inexperienced readers, on the other hand, spent relatively stable amounts of processing time over the three readings.

These data suggest a greater information gathering capability and degree of cognitive efficiency as foreign language proficiency increases; moreover, qualitative analysis of textual features suggests that experienced non-native readers of German exhibit processing

characteristics more akin to those of the native readers. Thus, with increased proficiency, non-native readers may be moving away from strategies that proved effective in reading their native language. More specifically, Bernhardt's (1985) data showed that natives and experienced non-natives attended more to function words than did the inexperienced readers. Research has demonstrated (Carpenter & Just, 1983) that in L1 studies of English, function words receive less attention than words carrying more of the semantic load, suggesting the possibility that the inexperienced readers of German are transferring their L1 reading strategies at the expense of gaining critical information from textual elements that serve to enhance comprehension.

Although these studies provide invaluable insights into the behaviors employed by natives and non-native learners reading different languages, our data base remains quite limited, and our empirical findings often seem contradictory. Clearly, new eye-tracking studies as well as replications need to be performed with different populations to validate the generalizability of our research findings. The present study, then, is meant to serve as a first attempt to link three areas that have received attention through separate investigation. These three areas are: the measurement of eye movements while reading Chinese; the measurement of eye movements while reading a foreign language, and the investigation into reading behaviors when word boundary clues are manipulated.

### CHAPTER III

#### DESIGN AND PROCEDURES

##### Population and Sample

The population from which samples were drawn consisted of native speakers of Chinese and non-native learners of Chinese enrolled at The Ohio State University (OSU). For purposes of this study, non-native learners of Chinese have been categorized as Beginning and Advanced.

Beginning students were those non-natives selected from Chinese 206, the Spring Quarter course offered in the second year Chinese language sequence. Students in this sequence have learned approximately 1000 Chinese characters over their two years of study in addition to concentrating upon the development of reading skills. Students in this course have typically learned their first year of Chinese through the Chinese 100 series offered at OSU and have not as yet spent study time in a Chinese speaking area of the world.

Subjects making up the Advanced level were learners of Chinese who had already studied the equivalent of at least four years of Chinese and were enrolled in a graduate level degree program in Chinese at OSU. Learners at this level have amassed a sizeable character inventory due to their study of modern and classical Chinese literary texts as well as everyday newspaper readings. Moreover,

students at this level of study have typically spent some time in a Chinese speaking area either working or participating in study abroad programs.

In addition to the non-native learner categories described above, native Chinese subjects also participated in the experiment. Subjects comprising this category were graduate students at OSU and were exclusively from the People's Republic of China. This stipulation was made by the researcher to control for variations in textual layout as texts printed in the People's Republic are printed horizontally from left to right, similar to the printed layout of English language texts. Other Chinese speaking areas, such as Taiwan, still typically print reading materials using a vertical column, right-to-left reading format. By using subjects exclusively from the People's Republic, all subjects would read the experimental texts in a printed format to which they were accustomed.

All subjects participating in the experiment were volunteers who were paid five dollars for their participation. With the help of professors in the Department of East Asian Languages and Literatures, students were notified and scheduled for participation in the experiment which was conducted during the month of May, 1986.

### Design

The present study employed a one-between one-within mixed, or "split-plot," design for statistical analysis (Figure 1). Such a design is suitable for experiments using small numbers of subjects.



<u>Variable B: SPACING</u>	
Normal Spacing	* Artificial Spacing
<u>Variable A:</u>	*
LANGUAGE ABILITY	*
	*
1 Beginning	*
	*
	*
2 Advanced	*
	*
	*
3 Native	*
	*

Figure 1: One-between (Language Ability) one-within (Spacing) mixed design.

Unlike a factorial design where subjects only receive one specific level of treatment, each subject in this experiment received all levels of the within-group independent variable, thus serving as their own "control." The first independent variable investigated in this study was Chinese Language Ability, a between-group factor consisting of three levels:

- 1 Beginning
- 2 Advanced
- 3 Native

The second independent variable was Spacing, a within-group factor consisting of two levels:

- 1 Artificially spaced
- 2 Normally spaced

A total of five dependent variables were evaluated in the study. They were:

- 1 Fixation Duration
- 2 Fixation Frequency
- 3 Percentage of Regressive Fixations
- 4 Reading Rate
- 5 Comprehension

### Materials

The stimulus used in this experiment consisted of a short paragraph of Chinese. It was taken from the book Read Chinese I (Wang, 1953), a book not used for Chinese instruction at OSU, but one

which is used at many other American institutions to train students to read sentences and stories using a lexicon of 300 characters. The paragraph chosen for the experiment was edited for considerations of space and consisted of 171 Chinese characters.

To form the two levels of the second independent variable (Spacing), the same paragraph was printed in two ways by a Xerox Star multilingual word processor. To represent the level termed "normally spaced," the characters in the paragraph were spaced apart from each other normally as they would be in a Chinese book, that is, with the spaces between each character being the same size of approximately .15 cm. The only exception to this rule was the spacing that followed punctuation marks. The paragraph in the level termed "artificially spaced," on the other hand, was printed so that there were spaces of .4 cm between each character or character group that represented a word-unit. In other words, combinations of two or more characters representing word-units were spaced together (approximately .15 cm apart) to denote their word-unit integrity, but a space of .4 cm set them off from other word-units in the text. This difference in spacing resulted in a difference in line length between the two versions. The normally spaced passage consisted of seven lines, and the artificially spaced passage consisted of nine lines.

To determine where the spaces should be placed, three non-native Chinese language specialists who have had over four years of study of the Chinese language were asked to read the normally spaced version of the paragraph and to mark boundaries between characters and/or

character combinations that could stand alone as integral word-units. Any disagreement between the three specialists was resolved by replacing controversial characters or character combinations with others that were unanimously agreed upon so that an internal consistency rating of 1.00 was finally agreed upon by the three specialists (See appendices H, I, and J).

The test stimuli were printed in two font versions, either employing simplified or traditional characters. Because this experiment deals primarily with the effects of spacing on the reading of Chinese, it was important that the subjects read characters with which they were most comfortable; therefore, the native Chinese from the People's Republic were given the passage written in simplified characters because these are what they typically read. Because beginning learners of Chinese typically learn traditional characters at the initial stages of their training, the Beginning subjects were instructed to read the stimuli printed in traditional characters. More advanced non-native readers, however, have developed varying degrees of proficiency in both types of characters depending upon their professional interests. Those interested in modern political science or literature, for instance, are probably more adept at reading simplified characters, while those interested in traditional literature have read primarily from sources employing traditional characters. The Advanced students, therefore, were given a choice as to which form of characters they would read.

### Experimental Procedures

The experimental procedures for this study were carried out during two separate sessions where repeated reading measures were obtained from each subject. When each subject appeared for the first session of testing, he/she was told that he/she was participating in an experiment designed to evaluate the eye movements of natives and non-natives while reading Chinese. Subjects were also told that when they were reading the stimulus, they could take as much time as they wished in order to read for comprehension because after reading the text, they would be required to perform a comprehension measure that involved writing down everything they could remember about the passage.

After these initial instructions, the subjects were stabilized in front of the stimulus with the aid of a chin rest designed to eliminate extraneous head movement. The stimulus was placed approximately 49.5 cm away from the subject so that the foveal area of acuity (two degrees of visual angle) took in approximately four character spaces, while the entire line length of the display measured from left to right (15.9 cm) encompassed approximately 18.2 degrees of visual angle. Subjects were also cautioned against extraneous head movement that could adversely affect eye movement measurement. Subjects were then permitted to read a normally spaced warm-up passage also printed by the Xerox Star.

After completion of the warm-up passage, the subjects read one version of the test passage. Which version of the text the subject read during the first session was randomized within each level of the Chinese Language Ability variable so that half of the subjects in each level read the normally spaced version during the first session, while the other half read the artificially spaced version. Upon completion, subjects were asked to recall in writing the contents of the paragraph so that comprehension could be assessed. To control for the varying degrees of English language expression among the native Chinese, subjects were told to write the comprehension measure in their native language. Before being dismissed, subjects were requested not to discuss the experiment with other subjects until the second phase of the experiment was completed for all participants.

The second phase of the experiment consisted of the subjects reading the version of the text that they did not read during the first session. This second phase was conducted during the last week in May, thus making the time between the two sessions approximately three weeks. In addition to randomizing the order of the text version that the subjects read, a three week interim between sessions was built into the experiment to attenuate any possible "learning effects" resulting from having read the two versions of the stimuli during the same session, or during sessions separated by only a few days. As was done during the first session, subjects were given the same instructions and were given a warm-up passage to read. Upon completion of the warm-up, subjects read the version of the stimuli

that they did not read during the first session and then completed another recall-protocol comprehension exercise.

#### Data Collection and Instrumentation

Data collection for four of the dependent variables was accomplished with the aid of a Micromeasurements System 1200 Eye Monitor interfaced with an IBM Personal Computer. The System 1200 is a video based, microcomputer controlled eye monitoring system designed to measure pupil area as well as horizontal and vertical eye movement. Subjects' eye movement parameters were collected and quantified by a computer program written especially for the measurement of the dependent variables investigated in this study. The information gained from each subject was transferred to magnetic disc for storage and subsequent analysis.

The dependent variables measured by the System 1200 were:

1. reading rate, or the total number of Chinese characters read per minute;
2. fixation duration, or the average time per fixation measured in milliseconds that the subject's eye stopped for information acquisition. An eye movement was considered a fixation if it lasted longer than 50 msec and had a saccade on either side of it;
3. fixation frequency, or the number of times during the reading passage that the eye stopped to fixate, and the
4. percentage of regressive fixations, or the percentage of fixations used to backtrack over portions of the text already scanned

by the reader.

Comprehension was the only dependent variable not evaluated by the System 1200 and was instead assessed by the recall-protocol measures written by the subjects. Scoring instruments based upon the stimulus passages were developed by dividing the text into constituent structures yielding nouns, verbs, and prepositional phrases that were awarded points when they appeared in the subject's written protocol (Meyer, 1985). These points served as the subjects' comprehension score. The scoring instrument was developed by three Chinese language specialists and achieved an inter-rater reliability index of .93.

#### Data Analysis

The five dependent variables were subjected to separate two-way univariate analysis using the Statistical Analysis System (SAS) located on the mainframe computer at the Instruction and Research Computer Center OSU. This program is also capable of computing Dunn's test and Tukey's studentized range test, the post hoc procedures that were used to test the statistical significance between main effects and selected pairwise mean comparisons. The following null hypotheses were tested:

As demonstrated by dependent measures of reading rate, fixation duration, fixation frequency, percentage of regressive fixations, and recall measures of comprehension:

H<sub>0</sub> 1: There was no significant difference between the normally spaced text and the artificially spaced text.



H<sub>0</sub> 2: There was no significant difference between the three levels of Chinese language ability.

H<sub>0</sub> 3: There was no significant interaction between the spacing variable and the Chinese language ability variable.

### Pilot Study

Pilot testing of the experimental procedures took place during the month of April and included scrutiny of all phases of the experiment. The computerized protocol written for the IBM Personal Computer to collect data from the reading trials worked extremely well during the pilot testing, but modifications to the verbal instructions read to the subjects were made because further pilot testing highlighted their incompleteness. Pilot testing also forewarned that the beginning group of non-native Chinese language learners would have more trouble remaining stationary during the reading trials because of their increased time on task.

## CHAPTER IV

### ANALYSIS OF THE DATA

A large body of research evidence suggests that when the spacing between individual words in an English language reading passage is no longer present, the reader's ability to establish the lengths and gross shapes of the words in his/her peripheral vision is rendered inoperable. Consequently, experienced readers are forced to fall back upon the reading strategies of less mature readers that dictate letter-by-letter or word-by-word processing. The purpose of the present study was to explore whether manipulating the spacing within a Chinese language reading passage would have any effect upon the reading strategies of native and non-native readers of Chinese. In addition, this study also sought to provide baseline data on American learners involved in reading a language that necessitates an orthographic switch from their native language.

To assess the effect of spacing over different groups of Chinese language reader, one independent variable, Chinese Language Ability, was divided into three levels: beginning non-native, advanced non-native, and native reader. The second independent variable, Spacing, was divided into two levels: normally spaced, representing a

text where the spacing between characters was uniform as is typically the case in printed Chinese reading materials; and artificially spaced, where the same text was spaced so that compound character word-units were typographically set apart from one another. The five dependent variables measured in this study were: average fixation duration, average fixation frequency, percentage of regressive fixations, reading rate, and reading comprehension. The first four dependent variables were measured with the aid of a Micromeasurements System 1200 Eye Monitor. The fifth dependent variable, reading comprehension, was assessed through recall-protocols performed by the subjects after reading the passages.

The purpose of the present chapter is to report the analyses of the data after they were subjected to a one-between one-within analysis of variance. Each of the five dependent variables will be reported separately, beginning with a report on the  $F$  test for Chinese Language Ability X Spacing interaction, then working through the Chinese Language Ability and Spacing main effects, if their reporting is deemed appropriate.

Hypothesis 1A: There will be no significant interaction between the Chinese Language Ability variable and the Spacing variable as measured by average fixation duration. The null hypotheses of no interaction between the two independent variables was retained for fixation duration,  $F(2, 15) = 1.17, p > 0.33$ . It should be noted, however, that an examination of Table 1 shows a disordinal relationship between

Table 1  
Means and Standard Deviations of  
Average Fixation Duration as a Function of  
Chinese Language Ability and Textual Spacing

	<u>Normal Spacing</u>		<u>Artificial Spacing</u>		<u>Overall</u>	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
<u>Beginning</u>	317.83	118.58	336.33	116.34	327.08	112.41
<u>Advanced</u>	370.16	110.33	308.66	65.36	339.41	92.23
<u>Natives</u>	199.66	42.78	203.16	38.88	201.41	39.01
<u>Overall</u>	295.88	116.78	282.72	95.75	289.30	105.46

N=36, cell size=6

the fixation duration means within the two non-native groups; that is, the beginning non-native readers on the average fixated longer for the artificially spaced text ( $M = 336.33$  ms) than they did for the normally spaced text ( $M = 317.83$  ms). In contrast, the advanced group averaged longer fixation durations for the normally spaced text ( $M = 370.16$ ) than they did for the artificially spaced text ( $M = 308.66$  ms). Under the present analysis, however, this disordinal relationship could not be deemed statistically significant. One of the reasons that statistical significance was not attained may be due to the large within-group variability of the non-native groups. Even though Cochran's test for homogeneity of variance ( $\chi^2 = .42$ ) retained the null hypothesis of no difference among group variances at the .05 level, the high within-group variability tended to inflate the SB/A mean square error term, consequently weakening the ANOVA's capability of detecting a significant interaction.

Hypothesis 1B: There will be no significant difference between the three levels of Chinese Language Ability as measured by average fixation duration. Table 1 shows that the average fixation duration time for the beginning non-native readers was 327.08 ms and 339.41 ms for the advanced non-native readers. The native group fixated an average time of 201.41 ms. The analysis of variance revealed significant differences between groups and thus led to a rejection of the null hypothesis,  $F(2, 15) = 6.26$ ,  $p < .02$ . Further main effect analysis using Tukey's studentized range revealed that the two

non-native groups were not significantly different from one another, but that both were significantly different from the native group.

This finding points out interesting differences when learners are involved in reading a text in a language that involves an orthographic switch. Stern (1978), for instance, found that Chinese readers with 7 to 14 years of experience with English did not differ in terms of fixation duration from native American readers, but Peng et. al (1983) found that their native Chinese group did indeed fixate for longer durations than did their American counterparts. What is more provocative in terms of the present study is that the beginning non-native readers and the advanced non-native readers of Chinese did not have an average fixation duration that was significantly different. Such a finding is not consistent with the Bernhardt (1985) results where the advanced non-native group of German language learners had an average fixation duration that was significantly less than that of the group of more inexperienced German language learners. Such a finding attests to the demands of the Chinese orthography in terms of how much time the non-natives were required to use in sampling the text, regardless of their experience level.

These data have interesting implications for Bernhardt's (1985) assertion that learners of languages employing different orthographies must pass through different stages of perception and development. In the case of fixation duration, although the advanced non-native group appears less variable, the two non-native reading groups are fixating for durations not significantly different from each other, yet the

native group's fixation duration average is significantly less. Thus, it can be seen that even though the analyses of other eye tracking variables will demonstrate that the advanced non-native readers read more efficiently than the beginning non-native readers, fixation duration was not a measure that worked to the advantage of the advanced non-natives. In other words, there may be a fixation duration plateau that non-native readers of Chinese reach in their language learning experience that, unlike other measures of eye movement, may be more resistant to change, thus hampering the development of automaticity in reading.

Hypothesis 1C: There will be no significant difference between the normally spaced text and the artificially spaced text as measured by average fixation duration. Table 1 reveals that the mean fixation duration for the normally spaced text was 295.88 ms and 282.72 ms for the artificially spaced text. The analysis of variance revealed that these two means were not significantly different,  $F(1, 15) = 0.34$ ,  $p > 0.56$ , thus leading to retention of the null hypothesis.

It should be noted that this was a test of the overall main effect for the difference between the normally spaced text and the artificially spaced text when combined over all three levels of Chinese language ability. Its non-significance therefore rejects the notion that spacing the characters into word-units affects the average fixation duration of native or non-native readers of Chinese.

Hypothesis 2A: There will be no significant interaction between the Chinese Language Ability variable and the Spacing variable as measured by average fixation frequency. The analysis of variance for rejection of the null hypothesis for interaction between the two independent variables was significant for fixation frequency,  $F(2, 15) = 4.09$ ,  $p < .05$ . Figure 2 portrays the disordinal nature of the interaction, and illustrates that the differential spacing of the text was most disruptive to the advanced non-native group. Post-hoc  $F$  tests used to assess simple main effects revealed that the average fixation frequency of the non-native advanced group differed significantly between the two spacing conditions,  $F(1, 15) = 8.86$ ,  $p < .01$ , but that this was not the case for the beginning non-native or the native groups.

This finding seems noteworthy for several reasons. First, disruption occurred again primarily in the advanced non-native reader, but for this dependent variable reached a level of significance at the .05 level. It seems that the advanced non-native readers have reached a level of familiarity with reading normally spaced Chinese texts, a level that is disrupted when the text is artificially spaced and consequently results in less efficient sampling as evidenced by the increased number of fixations.

Secondly, this could be interpreted to mean that the advanced non-natives may be beginning to acquire more automatic strategies in reading normally spaced Chinese text, but still do not have the strategic flexibility to cope with typographical aberration. The



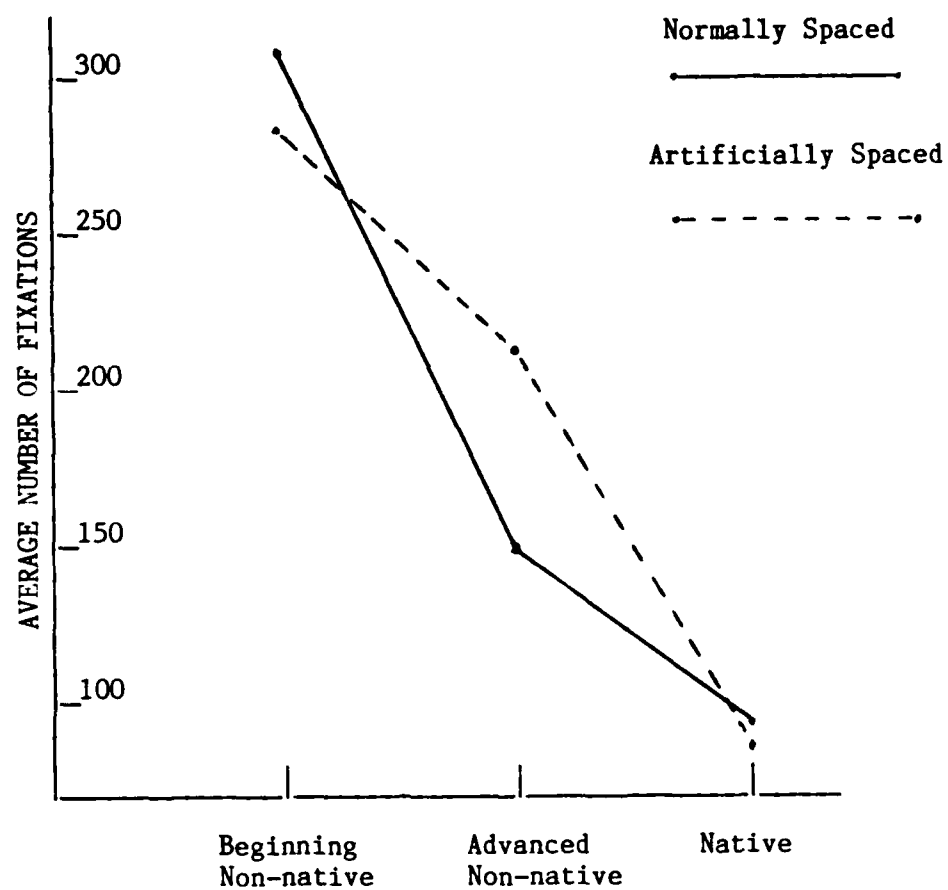


Figure 2: Interaction Between Chinese Language Ability and Spacing as Measured by Fixation Frequency

beginning non-native readers, on the other hand, may not as yet have acquired a consistent strategy for reading Chinese orthography as witnessed by the fact that their fixation frequency did not change significantly between spacing conditions. The same could be said about the native readers, except that instead of a lack of familiarity with the orthography, a total familiarity with it has inculcated strategies so flexible that the spacing in the text was virtually ignored.

Finally, these findings demonstrate one of the differences between English and Chinese orthography. In experiments involving native readers of English where the spaces between English words have been filled in, or eliminated altogether by printing words directly next to one another, it is hypothesized that the peripheral vision so necessary to prescreen word shape and length has been rendered dysfunctional (Fisher, 1979a). This dysfunctionality consequently results in the mature reader resorting to word-by-word or letter-by-letter strategies that require smaller eye fixations. In the spacing condition created for this experiment, however, it must be remembered that the integrity of the individual Chinese character was not altered. That is, each character's individual features were not run together so as to be confused with those of adjacent characters. Thus, it would appear that as long as the integrity of the character is preserved, native readers do not differ in terms of fixation frequency between spacing conditions.

Hypothesis 2B: There will be no significant difference between the three levels of Chinese Language Ability as measured by average fixation frequency. Although it is often considered inappropriate to assess the main effects of independent variables separately in the presence of a significant interaction, it is important in this case to document the main effect for fixation frequency among the three Chinese language ability groups to obtain a better understanding of the development between the two non-native reading groups.

Table 2 reveals that the beginning non-native readers averaged a total of 293.75 fixations and advanced non-natives fixated on an average of 178.16 times. The native group averaged 90.58 fixations. The analysis of variance detected significant differences between language groups,  $F(2, 15) = 20.34$ ,  $p < .0001$ , thus rejecting the null hypothesis of no difference. Post-hoc testing in the form of Tukey's studentized range test revealed that all three groups were significantly different from each other ( $p < .05$ ).

It should be emphasized that this statistic has measured the difference between the three group means for fixation frequency measured over both readings. Such an index, then, is a measure of their performance in somewhat more general terms, and consequently does not render sufficient analysis when the significant interaction is taken into account.

In order to make a more thorough analysis, Tukey's standardized range test was performed to assess the differences between all possible pairwise mean comparisons. Tukey's test yielded a figure of

Table 2  
Means and Standard Deviations of  
Average Fixation Frequency as a Function of  
Chinese Language Ability and Textual Spacing

	<u>Normal Spacing</u>		<u>Artificial Spacing</u>		<u>Overall</u>	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
<u>Beginning</u>	302.33	95.93	285.16	78.11	293.75	83.88
<u>Advanced</u>	147.33	33.18	209.00	74.13	178.16	63.52
<u>Natives</u>	91.66	14.15	89.50	11.84	90.58	12.49
<u>Overall</u>	180.44	107.24	194.55	101.58	187.50	103.19

N=36, cell size=6

67.36 (  $p < .05$ ), indicating that regardless of the spacing condition, the advanced non-native readers fixated less than the beginning non-native readers. Also of interest is that when reading the normally spaced text, the difference between the fixation frequency of the advanced non-native readers and the native readers, although qualitatively different, was not statistically significant.

These findings point out that the difference between the two non-native groups seems to be in how frequently they stop to sample the text. It seems that the advanced non-native reader, even when disrupted by typographical manipulation that results in less efficient sampling, is still more automatic in his/her overall sampling of the text. When faced with a text that is more "natural" in its spacing, however, the advanced non-native is shown to be approaching sampling strategies more akin to his/her native counterpart.

Hypothesis 3A: There will be no significant interaction between the Chinese Language Ability variable and the Spacing variable as measured by the percentage of regressive fixations. The null hypothesis of no significant interaction between the two independent variables was retained for the percentage of regressive fixations,  $F(2, 15) = 0.29$ ,  $p > 0.74$ .

Hypothesis 3B: There will be no significant difference between the three levels of Chinese language ability as measured by the percentage of regressive fixations. Table 3 reveals that of all the fixations

Table 3  
Means and Standard Deviations of  
Regressive Fixation Percentage as a Function  
of Chinese Language Ability and Textual Spacing

	<u>Normal Spacing</u>		<u>Artificial Spacing</u>		<u>Overall</u>	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
<u>Beginning</u>	0.344	0.039	0.319	0.044	0.332	0.042
<u>Advanced</u>	0.260	0.046	0.241	0.075	0.251	0.060
<u>Natives</u>	0.220	0.039	0.179	0.061	0.200	0.053
<u>Overall</u>	0.275	0.066	0.246	0.083	0.261	0.075

N=36, cell size=6

performed by the beginning non-native readers, 33.2% were regressive; for the advanced non-natives, this percentage decreased to 25.1%, and decreased further to 20.0% for the native group. The analysis of variance detected significant differences between groups,  $F(2, 15) = 12.96$ ,  $p < .001$ , leading to a rejection of the null hypothesis. Post-hoc testing using Tukey's studentized range revealed that all three groups were significantly different from each other ( $p < .05$ ).

These findings concerning the percentage of regressive fixations are not consistent with other second language eye tracking studies investigating English and German. Oller and Tullius (1975), for example, found that the native and non-native readers of English did not differ significantly in terms of regressive eye movements, and Bernhardt (1985) found similar evidence in her study of native and non-native readers of German. Peng et al. (1983), and Stern (1978), however, found that Chinese readers of English did differ significantly from native American readers in making more regressive fixations when reading English. This suggests that regressive fixation may be a more likely occurrence when learners of Chinese and English begin reading in the other's language, thus illustrating the informational processing demands inherent in the orthographic switch. In the present study, this phenomenon not only manifested itself, but also formed a distinct pattern of decrease as competence in the language increased, signifying development of automaticity in the advanced non-native group.

Hypothesis 3C: There will be no significant difference between the normally spaced text and the artificially spaced text as measured by percentage of regressive fixations. The analysis of variance for the spacing variable revealed a significant main effect for spacing,  $F(1, 15) = 5.36$ ,  $p < .05$ , thus leading to rejection of the null hypothesis. Table 3 illustrates that in reading the normally spaced text, of all the fixations made by the readers, 27.5% of them were regressive; when reading the artificially spaced text, 24.6% of the fixations were regressive. Post-hoc tests of within-group pairwise comparisons, however, did not reveal any significant differences. That is, when the mean for the percentage of regressive fixations performed by one group while reading the normally spaced text was compared to that same group's reading of the artificially spaced text, Dunn's test for three pairwise comparisons did not detect significant differences at the .05 level. Therefore, although it seems that the artificially spaced text led to an overall decrease in the percentage of regressive fixations across groups, a more focused analysis did not reveal significant differences due to spacing within each particular language group.

Hypothesis 4A: There will be no significant interaction between the Chinese Language Ability variable and the Spacing variable as measured by reading rate. The analysis of variance revealed no significant interaction between the two independent variables as measured by reading rate,  $F(2, 15) = 0.31$ ,  $p > 0.46$ . An examination of Table 4 illustrates that the increased fixation frequency experienced by the



Table 4  
Means and Standard Deviations of Reading  
Rate in Characters per Minute as a Function of  
Chinese Language Ability and Textual Spacing

	<u>Normal Spacing</u>		<u>Artificial Spacing</u>		<u>Overall</u>	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
<u>Beginning</u>	108.50	15.04	106.66	16.56	107.58	15.11
<u>Advanced</u>	194.16	79.59	158.50	32.37	176.33	60.84
<u>Natives</u>	546.33	172.02	552.83	190.44	549.58	173.05
<u>Overall</u>	283.00	220.54	272.66	230.40	227.83	222.34

N=36, cell size=6

advanced non-native readers when reading the artificially spaced text has manifested itself in the form of a reduced reading rate ( $M = 158.50$  CPM) when compared to their rate while reading the normally spaced text ( $M = 194.16$  CPM). This difference, however, was not large enough to cause a significant interaction. The means and standard deviations of the other two groups, however, remain quite constant across spacing conditions.

Hypothesis 4B: There will be no significant difference between the three levels of Chinese language ability as measured by reading rate.

Table 4 illustrates that the beginning non-native group read at a mean rate of 107.58 characters per minute, and the advanced non-native group at a mean rate of 176.33 characters per minute. The native group averaged a rate of 549.58 characters per minute. The analysis of variance revealed a significant difference between groups,  $F(2, 15) = 29.26$ ,  $p < .0001$ , leading to rejection of the null hypothesis. Post-hoc testing employing Tukey's studentized range revealed that all three groups were significantly different from each other ( $p < .05$ ).

These results are consistent with the assertion put forth by perceptual reading model proponents that individuals with more reading experience are more efficient in gathering and processing information, thus resulting in a higher reading rate. One of the more interesting findings was that the variability within each group actually increased with experience. This could be due to the fact that the beginning non-native readers approach all reading tasks in the same manner; that

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is, all reading tasks at this level require sampling strategies that are very deliberate and uniform in nature. The advanced non-native and native readers, on the other hand, seem to be more variable as individual readers in that some approached the task using deep sampling strategies, while others seemed to have merely skimmed the text.

Hypothesis 4C: There will be no significant difference between the normally spaced text and the artificially spaced text as measured by reading rate. Table 4 reveals that the normally spaced text was read by all three groups at an average rate of 283.00 characters per minute; the artificially spaced text was read at an average rate of 272.66 characters per minute. This difference was not considered significant through analysis of variance,  $F(1, 15) = 0.52$ ,  $p > .48$ , leading to retention of the null hypothesis.

Hypothesis 5A: There will be no significant interaction between the Chinese Language Ability variable and the Spacing variable as measured by scores of reading comprehension. Appendix G shows the scoring device created for the Chinese text used in the experiment, which is presented in Appendices H and I. One point was awarded for each proposition noted on the subject's recall-protocol, yielding a total possible score of 147 points. Table 5 shows the means and standard deviations for the comprehension scores. As with the fixation duration variable previously discussed, disordinality among cell means

Table 5  
Means and Standard Deviations of  
Reading Comprehension as a Function of  
Chinese Language Ability and Textual Spacing

	<u>Normal Spacing</u>		<u>Artificial Spacing</u>		<u>Overall</u>	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
<u>Beginning</u>	70.83	25.27	83.16	16.53	77.00	21.35
<u>Advanced</u>	96.66	17.53	95.16	15.61	95.91	15.84
<u>Natives</u>	101.00	15.44	96.33	15.57	98.66	14.98
<u>Overall</u>	89.50	23.15	91.55	16.15	90.52	19.70

N=36, cell size=6

is present because the beginning students showed a higher comprehension index after reading the artificially spaced text ( $M = 83.16$ ) than with the normally spaced text ( $M = 70.83$ ). Again, however, even though Cochran's test for homogeneity of variance ( $\chi^2 = .41$ ) retained the null hypothesis of no difference between group variances at the .05 level, it appears that high variability within the beginning non-native group made the analysis of variance less statistically powerful, so the null hypothesis of no interaction between the two variables was retained,  $F(2, 15) = 2.35$ ,  $p > 0.12$ .

Hypothesis 5B: There will be no significant difference between the three levels of Chinese language ability as measured by scores of reading comprehension. Table 5 shows that the beginning non-native group scored an average of 77.00 points on their recall protocols, and the advanced non-native group scored an average of 95.91 points. The native readers scored an average of 98.66 points. The analysis of variance failed to detect a difference between these three groups,  $F(2, 15) = 3.07$ ,  $p < .08$ , so that the null hypothesis was retained at the .05 alpha level.

Hypothesis 5C: There will be no significant difference between the normally spaced text and the artificially spaced text as measured by scores of reading comprehension. Table 5 shows an average reading comprehension score of 89.50 for the normally spaced text and 91.50 for the artificially spaced text. This difference was not deemed

significant by the analysis of variance,  $F(1, 15) = 0.36$ ,  $p > 0.55$ , thus retaining the null hypothesis of no difference between spacing conditions.

## CHAPTER V

### SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

#### Overview

The purpose of this study has been twofold: first, to add to the disappointingly small collection of eye tracking studies investigating the eye movements of native readers of Chinese, and to include for the first time American readers who are studying Chinese as a foreign language. Secondly, this study has investigated how a reading passage written in Chinese characters affects the reading strategies of both native and non-native readers when it is typographically spaced into word-units. Because the effects of spacing have been well documented among readers of English, this study can thus be looked upon as an investigation into the effects of word-unit spacing across two different orthographies.

#### Summary of Findings and Conclusions

Much of the data generated by this study supports Bernhardt's (1985) assertion that perceptual models of reading may prove useful for mapping and explaining the reading development of individuals learning non-Western languages and languages that employ non-Western

orthographies. Perceptual models tend to emphasize reading development in terms of how efficient the reader is in perceiving the printed word. Because perceptual model proponents believe that the overall act of reading can be broken down into various perceptual subskills such as feature detection and word perception, indices such as reading rate and comprehension are often used to demonstrate whether or not a reader has achieved sufficient mastery and flexible usage of these subskills during different stages of his/her reading development.

LaBerge and Samuels (1974) view the reading development process in terms of how much "automaticity" the reader has attained through familiarity and experience with the printed word. The LaBerge and Samuels model of reading states that readers have only so much "attention" that can be allocated between decoding and comprehending a text. If attentional units have to be allocated to decoding, there will be none left for allocation to the higher order processing stages; consequently, if beginning readers have not yet reached the stage where graphemic decoding skills are automatic, they must resort to inefficient "attention switching" strategies, first decoding the text and then processing the information at a higher level for meaning storage. The present study, then, is valuable in that it can pinpoint strategies that seem to differ over groups who have acquired different degrees of automaticity with reading Chinese orthography.



An analysis of the reading comprehension measures in this study demonstrated that the beginning non-native readers did not score significantly lower in the comprehension of the first-year reading passage than the other two groups, although there was significance at the .08 level. What becomes of interest, then, is comparing the eye movement behaviors of the three groups in order to document and infer differential attention allocation strategies. In a sense, we are trying to determine the perceptual price paid in attentional units for the gains achieved in comprehension. The answer to this becomes quite evident when the beginning non-native readers and the native readers are compared. They differed significantly from each other across measures of all the eye tracking variables. That is, it was necessary for the beginning non-native readers to fixate more frequently and for longer duration, in addition to regressing over parts of previously read text at a significantly higher percentage rate. This combined effect naturally resulted in a huge disparity in the reading rates between the two groups.

What were possibly the more thought provoking data, however, were those generated by the advanced non-native readers. Their greater facility with the language as compared with the beginning group was manifested in decreased fixation frequency, a lesser percentage of regressive fixations, and a higher overall reading rate. Indeed, the difference in degrees of automaticity between the two non-native groups seems to be reflected in the increased fixation frequency and percentage of regressive fixations performed by the beginning group,

suggesting a repeated sampling of each character so as to perceptually verify its composition and thus confirm hypotheses as to its makeup.

Interestingly enough, although the native reading group had an average fixation duration that was significantly lower than both non-native groups, the advanced non-native group did not differ significantly from the beginning non-native group as measured by average fixation duration. These data are at odds with the findings of Bernhardt (1985) where inexperienced non-native readers of German fixated for longer durations than their experienced non-native counterparts. This contrast potentially highlights fixation duration as the variable that reflects the processing demands required of foreign language students learning to read in an orthographic system that is substantially different from the one representing their native language. Whether non-native readers of Chinese as a population stagnate at a fixation duration plateau that is highly resistant to change and which hampers their development towards native-like automaticity becomes a vital question in need of further research.

#### The Issue of Spacing

The issue of typographical spacing has been integrated into the LaBerge and Samuels (1974) model by Fisher (1979a) in order to account for the contribution of peripheral prescreening to the concept of automaticity. Based largely on the constructs of PS (peripheral search guidance) and CSG (cognitive search guidance) as proposed by Hochberg (1970; 1976), Fisher contends that the initial

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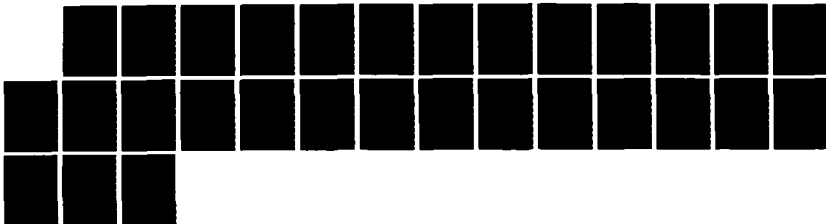
THE EFFECT OF WORD-UNIT SPACING UPON THE READING  
STRATEGIES OF NON-NATIVE. (U) AIR FORCE INST OF TECH  
WRIGHT-PATTERSON AFB OH H E EVERSON 1986  
AFIT/CI/NR-87-230

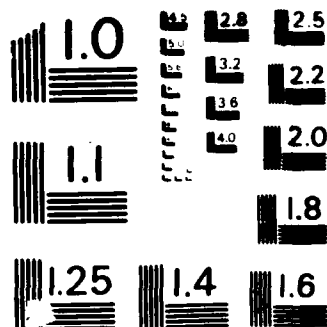
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MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS - 1963

inherent in CSG heighten the reader's expectations; these in turn then interact with the prescreening of word shape and word length in the peripheral vision field to select where readers should look next. Fisher asserts that as facility with perceptual extraction increases, the role of PSG will also increase because more attention can be allocated for peripheral prescreening. When the periphery is rendered unuseable through various forms of textual mutilation, however, the role of PSG is neutralized, causing mature readers to rely on "tunnel vision" strategies that dictate processing within the foveal area of visual acuity.

The results of this study indicate that native Chinese readers can sample larger areas of text as evidenced by their fixation frequency patterns, but it is difficult to assess the role of peripheral vision due to the fact that the computer program used to analyze the data for this experiment was incapable of localizing the points of the readers' fixations on the printed page. It should be pointed out, however, that even if this were possible, more sophisticated technology such as that employed by the numerous McConkie and Rayner studies using the "moving window" paradigm are more appropriate to gain a true picture of a Chinese reader's perceptual span.

Yet, this study can put forth some hypotheses about the spacing of Chinese characters as it affects native and non-native readers when the spacing does not destroy or disguise the integrity of the individual character. The advanced non-native group, for instance,

separated itself from the other two groups in being more affected by the artificial spacing condition. While reading the passage in the artificially spaced condition, they fixated significantly more times than they did while reading the normally spaced text. Similar disruption was not noted in either the beginning non-native readers or the native readers. This disruption may be due to the fact that the advanced non-native reader has developed a set of perceptual strategies capable of coping with the demands of the visual array presented in a normally spaced Chinese reading passage. Indeed, the statistical analysis showed that their fixation frequency patterns while reading the normally spaced text were not significantly different from those of native readers, thus bearing witness to the development of automaticity in this area. Yet, when the text was artificially spaced, comprehension among the advanced non-natives did not suffer, but the efficiency of the ocular guidance system was hampered to such a degree that more fixations were required to cope with the presence of the spacing.

The native readers, however, were not significantly affected by either textual spacing condition, thus testifying to the robustness of their reading strategies. Yet, it should be emphasized that the spacing of the characters into word-units differs qualitatively from the spacial mutilations done in the English language experiments in that the spacing of the two textual conditions in this experiment still maintained the minute spacing between individual characters. Consequently, the only problem for the PSG was to detect the smaller

spaces between characters in the normally spaced condition, and the larger spaces between word-units in the artificially spaced condition. The data indicate that this presented no problem at all for the native readers. An experiment more analogous to those mutilating the spacing of the English words would be one where the Chinese characters were typographically placed so closely together that the ability of the PSG to detect where one character began and one ended would be diminished. In this case, it is hypothesized that fixation frequency would increase dramatically and be accompanied by a decline in reading rate.

#### Recommendations for Further Research

It has been noted that the LaBerge and Samuels (1974) model conceptualizes the reading process as going through various stages, such as feature detection, letter coding, analysis of spelling patterns, and word code analysis. If this investigator were to name the most critical area in terms of needed research, it would be to investigate the strategies used by non-natives to encode Chinese characters in working memory.

Fortunately, recent work in this area has done much to debunk what DeFrancis (1984) refers to as the "ideographic myth," or "the concept of written symbols conveying their message directly to our minds, thus bypassing the restrictive intermediary of speech" (p. 133). Research conducted by Tzeng and Hung (1980) and Treiman, Baron, and Luk (1981) indicates that the extent of phonological encoding performed by Chinese readers is greater than had been originally

thought, leading Tzeng, Hung, and Garro (1978) to assert that phonological encoding may be an information processing strategy used in reading regardless of specific orthography.

If this is indeed the case, similar research needs to be carried out among non-native Chinese language learners to assess their processing strategies. One of the problems Chinese language learners are faced with in learning to read Chinese is the low sound to symbol correspondence when compared with languages employing alphabets or syllabary scripts, which hampers access into their aural/oral lexicon. If this problem results in retarding the development of a learner's ability to phonologically encode, he/she may compensate by overdeveloping processing strategies that are more visually oriented, thus reducing his/her ability to read a passage with flexibility and efficiency. Until this problem is investigated, it will be difficult to develop reading models that specifically detail the processing routes employed by non-native readers of Chinese.

Because this study is the first of its kind involving the eye tracking of American subjects reading Chinese, replications and enhanced experiments are certainly in order. As a first experiment, for instance, this investigator chose a reading passage that could reasonably be expected to be understood by all the groups involved in the experiment because his intention was to gather baseline reading data on non-natives reading a text that was not beyond their ability. Further research needs to be done with these same groups reading more cognitively and perceptually challenging texts. In this way, native



and non-native readers can be assessed in terms of the flexibility of their strategies when reading more demanding materials.

Certainly, the issue of character spacing requires more research. Although the equipment necessary to run certain experiments involving paradigms such as the "moving window" technique is undoubtedly expensive to acquire or program, it is important that we come to understand the role of the periphery in reading Chinese. Unlike English words, Chinese characters are allotted the same horizontal space on the printed page regardless of their stroke density. It is yet to be empirically established how the PSG is affected by this visual array. It is possible, for instance, that the block-like nature of the character may tend to disguise the stroke composition of the individual character in the peripheral field, thus making the PSG qualitatively different for readers of Chinese orthography.

Finally, replications of the present experiment need to be performed in order to scrutinize trends that manifested themselves among the three reading groups, but which did not turn out to be significant in the statistical analysis. Beginning non-native readers, for instance, seemed to comprehend better when reading the artificially spaced text, although this effect did not cause a significant interaction in the analysis. Advanced non-natives tended to fixate somewhat longer when reading the normally spaced text, but again there was no interaction effect. It is therefore quite obvious that if these findings are to be reported with confidence in their external validity, replications will be necessary. Additionally, more

research needs to be done to investigate further the possibility that native-like measures of fixation duration may be slow in developing for even the more advanced non-native readers of Chinese. This study has suggested that Chinese orthography may make processing demands on non-native readers that result in high fixation durations in both beginning and advanced non-native readers. It is also possible that the advanced non-native readers are relying upon reading strategies that militate against more rapid and efficient information processing. What remains to be discovered, then, is whether reading instruction can be implemented that will encourage strategies which decrease fixation duration for the developing non-native reader of Chinese.

#### Implications for Pedagogy

It is somewhat difficult to take the findings of this study and apply them directly to Chinese language pedagogy because the two different spacing conditions were presented to learners who had already achieved varying amounts of reading skill in Chinese. To say, then, that spacing Chinese character combinations together and apart from other character combinations in our basic readers will make no difference in aiding the development of reading skills is an overgeneralization of the findings of this study. What these findings do suggest, however, is that the advanced non-natives have developed a familiarity and facility with normally spaced text to the extent that typographical manipulation results in inefficient processing strategies as evidenced by increased fixation frequency. Therefore,

manipulation of the visual array for this level of learner may be inappropriate.

With regard to the LaBerge and Samuels (1974) model of reading, Kamil (1986) notes, "while almost all of the (reading) models would have to predict large amounts of practice for readers to become proficient, the LaBerge and Samuels model requires (emphasis his) practice to automate reading skills" (p. 86). Most Chinese language learners begin the task of learning to read by attempting to automate their character recognition skills through the use of flashcard drills employing individual or combinations of characters on one side, with the romanization and English translation on the reverse. Although this "brute force" approach to literacy seems to be inevitable during the initial stages, instructors would do well to encourage students to read paragraph-level texts sooner, and to read these same texts often. This enables the learner to take advantage of the context and redundancy inherent in longer passages, and can have the potential of instilling in the learner that the passage itself can provide clues to the meanings of characters not in their vocabulary. Also, classtime can be devoted to exercises designed to encourage as well as enhance the learner's silent reading skills. All too often, reading aloud is used as a classroom vehicle for teaching reading comprehension, in spite of current research that highlights the futility of this endeavor (Bernhardt, 1983).

### Limitations of the Study

Any researcher interested in studying group contrasts among learners of Chinese will probably have to resign him/herself to the inevitability of small sample sizes. Such a problem will no doubt limit the researcher's ability to conduct ambitious factorial studies involving large cell n's. This investigator also found large variability within groups to be of concern. Generally speaking, the analysis of variance model can withstand this variability so long as its model assumptions of homogeneity of variance are not grossly violated; unfortunately, the tradeoff for being able to operate with increased variability is that the error terms used to compute the mean squares for  $F$  ratio computation are often inflated, resulting in less statistical power for determining a difference between mean group performances. This problem of diminished statistical power is, of course, further exacerbated when one considers the limitation of small sample sizes as mentioned above. If researchers were afforded the luxury of having a considerable number of subjects, they might do well to make the groups as homogeneous as possible through pre-testing or the gathering of survey information that establishes group membership through rigorous categorization. Unfortunately, learners with extensive knowledge of Chinese often have such diverse backgrounds and differing levels of competence over each of the four skills (i.e. reading, writing, speaking, and listening) that the problem of finding a group of advanced learners in one place that is indeed homogeneous may always be problematic.

APPENDIX A  
ANALYSIS OF VARIANCE OF  
AVERAGE FIXATION DURATION BY CHINESE LANGUAGE  
ABILITY AND TEXTUAL SPACING

Source	df	SS	MS	F	PR > F
<hr/>					
<u>Between Ss</u>	17	307565.13			
Language					
Ability (A)	2	139952.88	69976.44	6.26	0.0105
S(A)	15	167612.25	11174.15		
<u>Within Ss</u>	18	81724.50			
Spacing (B)	1	1560.25	1560.25	0.34	0.5698
AB	2	10850.00	5425.00	1.17	0.3360
SB/A	15	69314.25	4620.95		
<hr/>					
Total	35	389289.63			
<hr/>					

APPENDIX B  
ANALYSIS OF VARIANCE OF  
AVERAGE FIXATION FREQUENCY BY CHINESE LANGUAGE  
ABILITY AND TEXTUAL SPACING

Source	df	SS	MS	F	PR > F
<u>Between Ss</u>	17	341140.99			
Language					
Ability (A)	2	249228.16	124614.08	20.34	0.0001
S(A)	15	91912.83	6127.52		
<u>Within Ss</u>	18	31605.99			
Spacing (B)	1	1792.11	1792.11	1.39	0.2563
AB	2	10514.38	5257.19	4.09	0.0383
SB/A	15	19299.50	1286.63		
<u>Total</u>	35	372747.00			

APPENDIX C  
ANALYSIS OF VARIANCE OF REGRESSIVE  
FIXATION PERCENTAGE BY CHINESE  
LANGUAGE LEVEL AND TEXTUAL SPACING

Source	df	SS	MS	F	PR > F
<u>Between Ss</u>	17	0.7224			
Language Ability (A)	2	0.1064	0.0532	12.96	0.0005
S(A)	15	0.6160	0.0041		
<u>Within Ss</u>	18	0.0287			
Spacing (B)	1	0.0073	0.0073	5.36	0.0352
AB	2	0.0008	0.0004	0.29	0.7498
SB/A	15	0.0206	0.0013		
Total	35	0.1968			

APPENDIX D  
ANALYSIS OF VARIANCE OF READING RATE  
IN CHARACTERS PER MINUTE BY CHINESE LANGUAGE  
ABILITY AND TEXTUAL SPACING

Source	df	SS	MS	F	Pr > F
<u>Between Ss</u>	17	1698635.00			
Language					
Ability (A)	2	1357624.50	678812.25	29.86	0.0001
S(A)	15	341011.50	22734.10		
<u>Within Ss</u>	18	31662.99			
Spacing (B)	1	961.00	961.00	0.52	0.4818
AB	2	2992.16	1496.08	0.81	0.4635
SB/A	15	27709.83	1847.32		
Total	35	1730299.00			



APPENDIX E  
ANALYSIS OF VARIANCE OF READING  
COMPREHENSION BY CHINESE LANGUAGE  
ABILITY AND TEXTUAL SPACING

Source	df	SS	MS	F	PR > F
<hr/>					
<u>Between Ss</u>	17	11496.46			
Language					
Ability (A)	2	3339.38	1669.69	3.07	0.0763
S(A)	15	8157.08	543.80		
<u>Within Ss</u>	18	2094.48			
Spacing (B)	1	38.02	38.02	0.36	0.5552
AB	2	490.38	245.19	2.35	0.1296
SB/A	15	1566.08	104.40		
<hr/>					
Total	35	13590.97			
<hr/>					

APPENDIX F  
ANALYSIS OF VARIANCE OF  
SIMPLE EFFECTS FOR FIXATION FREQUENCY

Source	df	SS	MS	F	PR > F
<u>Between Ss</u>					
Between A @ B1	2	143008.44	71504.22	19.28	.0001
Between A @ B2	2	116734.11	58367.05	15.74	.0001
Within cell	30	111212.33	3707.07		
<u>Within Ss</u>					
Between B @ A1	1	884.04	884.04	.68	NSD
Between B @ A2	1	11408.34	11408.34	8.86	.0091
Between B @ A3	1	14.07	14.07	.01	NSD
AB	2	10514.38	5257.19	4.08	.0378
BS(A)	15	19299.50	1286.63		
Total	35	272049.01			

A1= Beginning Non-natives  
A2= Advanced Non-natives  
A3= Natives

B1= Normally spaced  
B2= Artificially spaced

APPENDIX G  
COMPREHENSION SCORING DEVICE

- response
- problem
  - agent
  - I
  - DON'T KNOW
  - patient
  - WAY
  - covariance; antecedent
  - EATING
  - patient
  - DINNER
  - description; time
  - ONEDAY
  - description; time
  - AFTER
  - agent
  - I
  - description; setting
  - AT HOUSE
  - description; specific
  - FRIEND'S
  - consequence
  - WANTED TO GO
  - range
  - TO RAILWAY STATION
  - TO TAKE
  - instrument
  - TRAIN
  - range
  - HOME
  - solution
  - (ASK DIRECTIONS)
  - covariance; antecedent
  - SAW
  - agent
  - I
  - patient
  - MAN
  - setting; time
  - AFTERWARDS

- description; location
- ON STREET
- description; attribution
- agent
- HE
- WEARING
- patient
- CLOTHES
- description; attribution
- OLD
- patient
- HAT
- description; attribution
- OLD
- WALKED
- description; attribution
- SLOWLY
- description; setting
- DOWN (ON) STREET
- covariance; consequence
- agent
- I
- CROSSED OVER
- SAID
- patient
- HIM
- response: question
- EXCUSE ME
- HOW GET TO
- range
- RAILWAY STATION
- response: reply
- agent
- HE
- SAID
- GO
- description; manner
- NORTH
- patient
- YOU
- WILL GET
- range; description replacement for railway station
- THERE
- SAYING
- range
- THIS
- description; time
- AFTER
- SAID

-agent  
-HE  
-description; manner  
-AGAIN  
-comparison; alternative  
-NO NO  
-MUST GO  
-agent  
-YOU  
-description; manner  
-SOUTH  
-KNEW  
-agent  
-I  
-patient  
-HE  
-description; attribution  
-DRUNK/INTOXICATED  
-description; setting  
-AT THIS POINT  
-SAID  
-agent  
-HE  
-description; manner  
-AGAIN  
-comparison; adversative  
-TO GET TO  
-range  
-RAILWAY STATION  
-MUST GO  
-agent  
-YOU  
-description, manner  
-EAST  
-comparison; adversative  
-(GO)  
-(agent)  
-(YOU)  
-description, manner  
-WEST  
-comparison; adversative (NOT)  
-description, manner  
-EAST  
-LET THINK  
-agent  
-YOU  
-patient  
-ME  
-comparative, adversative  
-YES YES

- TO GET TO
- description; location
- FROM HERE
- description; manner
- NO WAY
- range
- RAILWAY STATION

APPENDIX H  
NORMALLY SPACED TEXT

有一天，我在朋友家裏吃完了晚飯以後，想到火車站去坐火車回家，  
可是我不認識路。後來，我在路上看見一個人。他穿着一件舊衣裳，  
戴着一個舊帽子，在街那邊走，走的很慢。我就過去問他說：「請問，  
到火車站去怎麼走？」他說：「你一直往南走就到了。」他說完了，又  
說：「不對，不對，你得往北走。」他說到這兒，我知道他是喝酒喝  
多了。他又說：「到火車站去得往東；不對，不對！不是往東，往西走。  
啊，你等我想想。對了！對了！從這兒沒有法子到火車站去。」

APPENDIX I  
ARTIFICIALLY SPACED TEXT

有 一 天，我 在 朋 友 家 裏 吃 完 了 晚 飯 以 後，想 到 火 車 站  
去 坐 火 車 回 家，可 是 我 不 認 識 路。後 來，我 在 街 上  
看 見 一 個 人。他 穿 着 一 件 舊 衣 裳，戴 着 一 個 舊 帽 子，  
在 街 那 邊 走，走 的 很 慢。我 就 過 去 問 他 說：「請 問，到  
火 車 站 去 怎 麼 走？」他 說：「你 一 直 往 南 走 就 到 了。」他  
說 完 了，又 說：「不 對，不 對，你 得 往 北 走。」他 說 到 這 兒，  
我 知 道 他 是 喝 酒 喝 多 了。他 又 說：「到 火 車 站 去  
得 往 東；不 對，不 對！不 是 往 東，往 西 走。啊，你 等 我  
想 想 對 了！對 了！從 這 兒 沒 有 法 子 到 火 車 站 去。」



APPENDIX J  
ENGLISH TRANSLATION OF READING STIMULUS

One day, after eating dinner at a friend's house, I wanted to go to the railway station to take the train home, but I didn't know the way. Afterwards, I saw a man on the street. He was wearing old clothes and an old hat, and walked slowly down the street. I crossed over and said to him, "Excuse me, how do I get to the railway station?" He said, "Go straight south and you'll get there." After saying this, he said again, "No, no, you have to go north." At this point, I knew he had been drinking a great deal. He said again, "To get to the railway station you must go east; no, not east, go west. Ummm, let me think. Yes! Yes! From here there is no way to get to the railway station."

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